



**T.C.
YEDİTEPE UNIVERSITY
INSTITUTE OF HEALTH SCIENCES
DEPARTMENT OF PEDIATRIC DENTISTRY**

**FREQUENCY OF STAINLESS STEEL CROWNS USE TO
RESTORE PRIMARY MOLARS:
A RETROSPECTIVE STUDY**

**DOCTOR OF PHILOSOPY THESIS
AYŞE SULTAN AĞIN, DDS**

İstanbul-2023



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AYŞE SULTAN AĞIN, DDS**

**SUPERVISOR
PROF. DR. DİDEM ÖZDEMİR ÖZENEN**

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THESIS APPROVAL FORM

Institute : Yeditepe University Institute of Health Sciences
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Owner of the Thesis : Dt. Ayşe Sultan AGİN
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This study have approved as a Master/Doctorate Thesis in regard to content and quality by the Jury.

	Title, Name-Surname (Institution)
Chair of the Jury:	Prof. Dr. Senem SELVİ KUVVETLİ
Supervisor:	Prof. Dr. Didem ÖZDEMİR ÖZENEN
Member/Examiner:	Prof. Dr. Elif SUNGURTEKİN EKÇİ
Member/Examiner:	Prof. Dr. Meltem ÖZDEMİR KARATAŞ
Member/Examiner:	Prof. Dr. Erman Bülent TUNCER

APPROVAL

This thesis has been deemed by the jury in accordance with the relevant articles of Yeditepe University Graduate Education and Examinations Regulation and has been approved by Administrative Board of Institute with decision dated and numbered

Prof. Dr. Bayram YILMAZ
Director of Institute of Health Sciences

DECLARATION

I declare that this thesis is my own work, that I have not had any unethical behavior at all stages from the planning to the writing of the thesis, that I have obtained all the information in this thesis within academic and ethical rules, that I have cited all the information and comments that were not obtained through this thesis study, and that I have included these sources in the list of sources.

Dt. Ayşe Sultan AGİN
20 June 2023



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LIST OF SYMBOLS AND ABBREVIATIONS

AAPD	:	American Academy of Pediatric Dentistry
ADA	:	American Dental Association
AHA	:	American Heart Association
ALARA	:	As Low As Reasonably Achievable
AMELX	:	Amelogenin
ART	:	Atraumatic Restorative Treatment
BSPD	:	British Society of Paediatric Dentistry
CGIC	:	Conventional Glass Ionomer Cement
CPP-ACP	:	Casein Phosphopeptide-Amorphous Calcium Phosphate
DI-FOTI	:	Digital Fiber Optic Transillumination Imaging
DPB	:	Dental Practice Board
EAPD	:	European Academy of Paediatric Dentistry
ECC	:	Early Childhood Caries
EPS	:	Extracellular Polysaccharide
FDA	:	Food and Drug Administration
FOTI	:	Fibre Optic Transillumination
FPM	:	First Permanent Molars
GDP	:	General Dental Practitioner
GI	:	Gingival Index
GIC	:	Glass Ionomer Cement
HT	:	Hall Technique
IAPD	:	International Association of Paediatric Dentistry
ICDAS	:	International Caries Detection And Assessment System
ITR	:	Interim Therapeutic Restorations
MG	:	Milligram
MIH	:	Molar Incisor Hypomineralisation
NHS	:	National Health Service
NILT	:	Near Infrared Transillumination
OHI	:	Oral hygiene Index
PEB	:	Post Eruptive Breakdown
QLF	:	Quantitative Light Fluorescence
RMGIC	:	Resin-Modified Glass Ionomer Cement
SDF	:	Silver Diamine Fluoride

SECC	:	Severe Early Childhood Caries
SMART	:	Silver Modified Atraumatic Restorative Technique
SNAS	:	Systemic Nickel Allergy Syndrome
SNP	:	Single Nucleotide Polymorphisms
SSC	:	Stainless Steel Crown
WHO	:	World Health Organization
ZC	:	Zirconia Crown



ABSTRACT

Agin AS. Frequency of stainless steel crowns use to restore primary molars: a retrospective study, Ph.D. Thesis, Yeditepe University, Institute of Health Sciences, İstanbul, 2023.

Objective: Many different ways to treat caries lesions in young children have been studied throughout history for their clinical efficacy and durability. According to these studies, the widespread use and good clinical performance of stainless steel crowns (SSC) have increased the frequency of preference for them. This thesis study aims to examine how the Department of Pediatric Dentistry at Yeditepe University's Faculty of Dentistry has changed its preference for stainless steel crown treatments in light of recent research.

Materials and Methods: Between January 2016 and December 2022, patients who were treated in Yeditepe University Dental Hospital's Pediatric Dentistry Department, and whose records were kept in the hospital's operating system, were evaluated. According to the years and the clinic in which it was done, the data collected by requesting it from the hospital operating system were categorized and submitted in the excel file. The data obtained in the study were analyzed using the IBM SPSS 22 (ver. 22.0, SPSS Inc, Armonk, NY, USA) program. The Kolmogorov-Smirnov test was used to assess if the study's data were normal. The number of SSC treatments carried out by year was compared using the Kruskal Wallis test to see whether there was a statistically significant difference. The effect of the pandemic on the shift in the number of SSC treatments was evaluated using the Mann Whitney U test. The Kruskal Wallis test was used to compare the treatments provided by general dentists, specialized dentists, and PhD students, as well as to assess the pandemic impact.

Results: When the data are reviewed, it is found that while the quantity of stainless steel crowns rose from 2016 to 2019, it declined slightly in 2020. As of 2021, the number of stainless steel crowns has increased again. According to statistics, there was a difference in the quantity of stainless steel crowns by year ($p < 0.05$). This distinction was made between stainless steel crown treatments carried out in 2022 and those carried out in 2016 and 2017.

Conclusion: Primary teeth are of great importance for the general health and development of the child. The treatment of caries in primary teeth should be done as soon as possible, taking into account factors such as the child's age, caries risk group, and the size of the caries lesion. Among these treatment options, pediatric crowns prepared from different materials are especially recommended for teeth with endodontic treatment and large caries lesions. Among pediatric crowns, stainless steel crowns are preferred due to their affordability, durability and easy application. Stainless steel crowns greatly contribute to the retention time of primary teeth by reducing the risk of secondary caries and preserving the structural integrity of the tooth. According to the results of this study, stainless steel crown procedures increased until the COVID-19 epidemic disturbed clinical applications. The fall in treatments observed in 2020 was followed by an increase in treatments once more in 2022 as the pandemic's influence diminished.

KeyWords: Caries risk assessment, early childhood caries, restorative treatment, stainless steel crowns

ÖZET

Agin AS. Süt azı dişlerini restore etmek için kullanılan paslanmaz çelik kuronların kullanım sıklığı: retrospektif bir çalışma, Doktora Tezi, Yeditepe Üniversitesi, Sağlık Bilimleri Enstitüsü, İstanbul, 2021.

Amaç: Çocuk hastalarda çürük lezyonlarını tedavi etmenin birçok farklı yolu, klinik etkinlikleri ve dayanıklılıkları açısından tarih boyunca incelenmiştir. Bu araştırmalara göre, paslanmaz çelik kronların yaygın kullanımı ve iyi klinik performansı, onlar için tercih sıklığını arttırmıştır. Bu tez çalışması, Yeditepe Üniversitesi Diş Hekimliği Fakültesi Çocuk Diş Hekimliği Anabilim Dalı'nın paslanmaz çelik kuron tedavilerine yönelik tercihini son araştırmalar ışığında nasıl değiştirdiğini incelemeyi amaçlamaktadır.

Gereç ve Yöntem: Ocak 2016-Aralık 2022 tarihleri arasında Yeditepe Üniversitesi Diş Hastanesi Çocuk Diş Hekimliği Anabilim Dalı'na başvuran ve tedavi gören (genel anestezi dahil) ve dosyaları hastane işletim sistemine kaydedilen hastalar incelendi. Hastane işletim sisteminden talep edilerek elde edilen veriler yıllara ve yapıldığı kliniğe göre kategorize edilerek excel dosyasına kaydedilmiştir. Araştırmada elde edilen veriler IBM SPSS 22 (ver. 22.0, SPSS Inc, Armonk, NY, ABD) programı kullanılarak analiz edilmiştir. Araştırmada verilerin normalliği Kolmogorov Smirnov testi ile belirlenmiştir. Yıllara göre yapılan paslanmaz çelik kuron (PÇK) tedavi sayıları arasında anlamlı bir fark olup olmadığını analiz etmek için Kruskal Wallis testi kullanılmıştır. Mann Whitney U testi, pandeminin PÇK tedavilerinin sayısındaki değişiklik üzerindeki etkisini değerlendirmek için kullanılmıştır. Diş hekimliği öğrencileri, doktora öğrencileri ve uzman diş hekimleri tarafından uygulanan tedaviler arasındaki farkın incelenmesi ve pandemi etkisinin değerlendirilmesi Kruskal Wallis testi ile yapılmıştır.

Bulgular: Sonuçlar değerlendirildiğinde 2016 yılından 2019 yılına kadar paslanmaz çelik kuron sayısı artmış ancak 2020 yılında bu sayı görece azalmıştır. 2021 yılı itibari ile paslanmaz çelik kuron sayısı tekrar artış göstermiştir. Yıllara göre paslanmaz çelik kron sayıları arasında istatistiksel olarak anlamlı bir fark bulunmuştur ($p<0.05$). Bulunan bu fark 2022 yılında yapılan paslanmaz çelik kaplama uygulamaları ile 2016 ve 2017 yıllarında yapılan paslanmaz çelik kaplama uygulamaları arasındadır.

Sonuç: Süt dişlerinin çocuğun genel sağlığı ve gelişimi açısından önemi büyüktür. Süt dişlerinde meydana gelen çürüklerin tedavisi, çocuğun yaşı, çürük risk grubu, çürük lezyonunun büyüklüğü gibi faktörler göz önünde bulundurularak en kısa sürede yapılmalıdır. Bu tedavi seçenekleri arasında farklı materyallerden elde edilen pediatrik kuronlar, özellikle endodontik tedavi görmüş, geniş çürük lezyonlu dişlerde tavsiye edilmektedir. Pediatrik kuronlar arasında bulunan paslanmaz çelik kuronlar hesaplı olması, dayanıklılığı, kolay uygulanabilirliğiyle tercih edilmektedir. Paslanmaz çelik kuronlar sekonder çürük riskini azaltıp, dişin yapısal bütünlüğünü koruyarak süt dişlerinin ağızda kalma sürelerine büyük ölçüde katkı sağlamaktadır. Bu çalışmanın bulgularına göre paslanmaz çelik kron tedavilerinde klinik uygulamaları sektöre uğratan COVID-19 pandemisine kadar bir artış olmuştur. 2020 yılında görülen tedavilerdeki düşüşün ardından 2022 yılında pandeminin etkisinin azalmasıyla birlikte bir kez daha artış görülmüştür.

Anahtar Kelimeler: Çürük risk değerlendirmesi, erken çocukluk çağı çürükleri, restoratif tedaviler, paslanmaz çelik kuronlar

1. INTRODUCTION AND PURPOSE

Dental caries is a disease having biological, physical, economic, social, and psychological consequences that is widespread in many countries and are categorized as infectious diseases which result in destruction of dental hard tissues (1,2).

Dental caries are still a major issue for both children and adults worldwide. Untreated early childhood caries (ECC) have a significant impact on children's health and growth (3,4). Children who have caries in their primary teeth have a three times greater chance of having caries in their permanent teeth (5).

The World Health Organization (WHO) claims that dental caries is the most prevalent disease in various Asian and South American nations, affecting 60–90% of the children (6-8). The World Health Organization's statistics indicate that the incidence of caries in developed countries reduced in 2006 as compared to 1970. This decline can be explained by a greater focus on oral health and the use of fluoride containing toothpastes. Despite this, the high priced treatments and inadequacies of the oral health sector contribute to the high incidence of caries in underdeveloped countries (9).

Nowadays, it is widely acknowledged that dental caries is a multifactorial disease. Progression of a caries lesion requires cariogenic bacteria, the biofilm that is formed on dental plaque, repeatedly consumed fermentable carbohydrates, low salivary flow rate and buffering capacity, and insufficient oral hygiene habits (10,11).

Primary tooth decay that is left untreated spreads quickly and results in material loss. Complex procedures may be necessary to treat teeth that have caries on multiple surfaces. Primary teeth may have more failure rates in caries treatment than permanent teeth. The causes of these include challenges in maintaining dental hygiene in children, differences in tooth morphology and chemical composition, and use of inappropriate materials. The use of crown restorations in primary teeth with significant material loss is seen to be a more accurate approach. Consequently, it may be assured that the primary teeth's mesio-distal dimension is retained, and the tooth's structural integrity is preserved (12).

From the past to the present, numerous treatment approaches have been tested for their clinical success and longevity in the treatment of caries lesions in pediatric patients. In line with these studies, the frequency of preference for stainless steel crowns has increased due to the wide usage area and high clinical success. Especially with the COVID-19 pandemic, it has been used and recommended more owing to the advantage of preventing aerosol as a result of the application of stainless steel crowns with the Hall technique. The aim of this thesis study is to

examine the changes in the frequency of preference of stainless steel crown treatments made in the Yeditepe University, Faculty of Dentistry, Department of Pediatric Dentistry, in line with current studies.

The null hypothesis of this study is that there has been no change in the number of stainless steel crown treatments applied in the Department of Pediatric Dentistry of Yeditepe University Faculty of Dentistry between 2016-2022.

The alternative hypothesis of this study is that there has been an annual increase in the number of stainless steel crown treatments applied between 2016-2022 in Yeditepe University Faculty of Dentistry, Department of Pediatric Dentistry.



2. GENERAL INFORMATION

2.1. Dental Caries in Pediatric Patients

Dental caries is an infectious disease caused by the acid produced by the fermentation of sugars in the diet by microorganisms in the biofilm, causing destruction by demineralization and destruction of enamel and dentin (13).

Caries develop more quickly in deciduous teeth than in permanent teeth because the structure of the enamel of deciduous teeth differs from that of permanent teeth (14). Until permanent teeth erupt, primary teeth provide the functions of phonation, aesthetics, and space holding. Consequently, keeping the deciduous tooth in the mouth until it is ready to exfoliate is crucial for the development of the jaw and permanent dentition (15).

Untreated dental caries can cause pain, infection and orthodontic problems in children (13). Children who have dental caries experience extreme pain, nutritional deficiencies as a result of chewing difficulties, speech disorders, and abscess formation, all of which have a negative impact on their quality of life (16).

For reasons including the significance of primary molar teeth on chewing function and the fact that it plays an important role in the development of occlusion, it is necessary to treat primary molar teeth in order to keep them in the mouth until the period of natural exfoliation comes. There are many material alternatives for the treatment of these teeth. The main ones are amalgams, glass ionomer cements, compomers, composite resins and pediatric crowns. Dentists should choose the material by considering many factors such as the patient's risk group, caries activity and age during the treatment (17).

Difficulties encountered in the treatment process of primary teeth (18):

- Compared to permanent teeth, primary teeth have a thinner enamel and dentin layer, and the pulp chamber is larger. Therefore, caries may progress to the pulp more rapidly and cause infection.
- The cooperation problem seen in young children complicates the procedures.
- Children's fear of the dentist may delay the necessary procedures.
- Due to the early loss of untreated teeth, space loss, speech and nutritional disorders can be seen.

2.2. Caries Formation

From the past to the present, a variety of hypotheses have been advanced explaining the initiation and progression mechanism of dental caries. The common point of the majority of

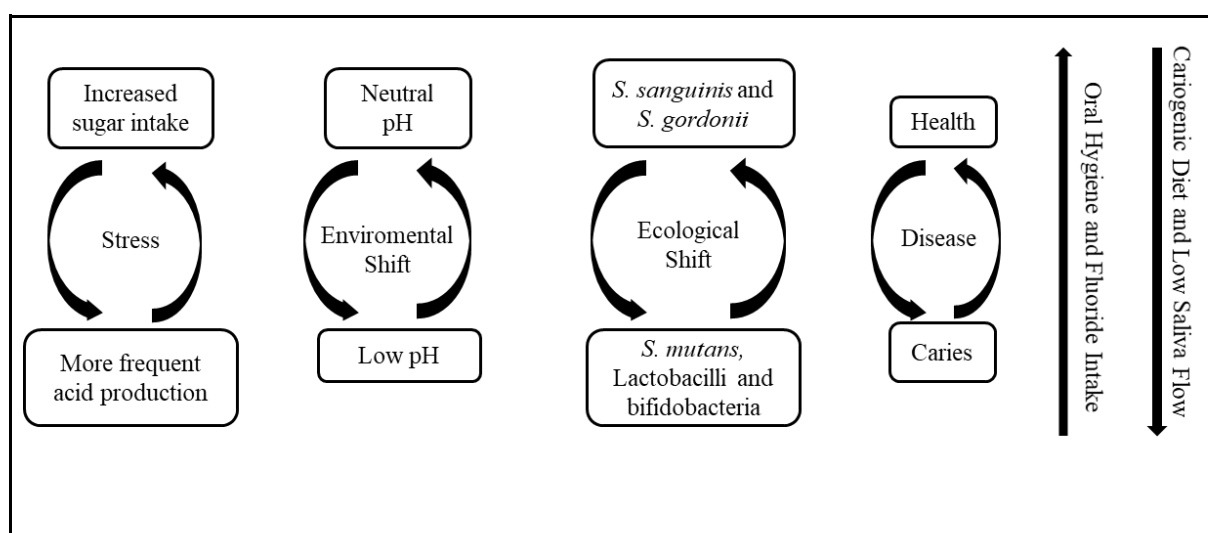
these ideas is that certain bacteria and acids cause the demineralization of tooth-hard tissues (19).

Cariogenic bacteria found in the oral biofilm metabolize fermentable carbohydrates that are consumed, and generate acids, mainly lactic acid (20). As a result of the metabolic activities of cariogenic microorganisms in the oral environment, the pH value reaches a critical level and caries lesions are seen as a result of the continuity of this event (21).

Demineralization results in an increase of the pores in the enamel structure which leads these caries forming byproducts of the cariogenic bacteria to penetrate the enamel more deeply and demineralize the mineral underneath the outer surface. Due to the continuous loss of minerals, white spot lesions are seen as a clinical sign of tooth decay (22). Once a white spot lesion occurs, with the help of changes in dietary habits, fluoride use, and other protective pathways, its progress can be prevented. If not, cavitation of the lesion may be seen due to the expanded porous structure of the tooth (23,24).

The demineralization and remineralization cycle continuously occurs during the day (23,24). As teeth first emerge in the mouth, they are most vulnerable to caries, but as time goes on, they grow more resilient to acid exposures (25).

Recently, theories describing the caries formation process have been developed. One of these concepts is the ecological plaque hypothesis. In this theory, bacterial functions (acid production, capacity to live in an acidic environment) and the environment required for caries formation (frequent sugar consumption, low salivary flow rate) are defined (Figure 1)(26).



The ecological plaque hypothesis describes the differences seen in the microbiota from sound and carious sites as a consequence of a change in oral environmental conditions. An increased frequency of fermentable sugar intake results in the biofilm spending more time at a low pH, which will select for bacteria that grow preferentially under acidic conditions. The growth of bacteria associated with sound surfaces is then disadvantaged, which over time results in an increase in the proportions and activity of cariogenic species at a site and a heightened risk of caries. This risk is raised in individuals with impaired saliva flow and sugar-rich diet, but it is reduced in those with appropriate oral hygiene and exposure to fluoride. *S. gordonii*, *Streptococcus gordonii*; *S. mutans*, *Streptococcus mutans*; *S. sanguinis*, *Streptococcus sanguinis*.

Figure 1: Ecological Plaque Hypothesis (26)

2.3. Caries Etiology

In humans, the development of caries is a process that is influenced by numerous variables. These elements may be divided into two categories: those that directly impact and those that indirectly affect. Direct-acting variables include oral care, the amount of dental plaque, whether oral bacteria are cariogenic, the type of diet, frequency of carbohydrate intake, the amount of salivary secretion and its ability to buffer the oral environment's acidic pH, and the use of fluoridated products. The factors that indirectly affect the formation of caries are; socioeconomic conditions such as general health and education status of the person, insufficient income, ignorance of the importance of oral care, and growing up in a family with low health literacy (27-29).

Dental caries occur as a result of the negative shift of the balance between cariogenic and preventive variables (Figure 2) which leads to disruption of the structural integrity of the tooth, causing pain and discomfort (10,11).

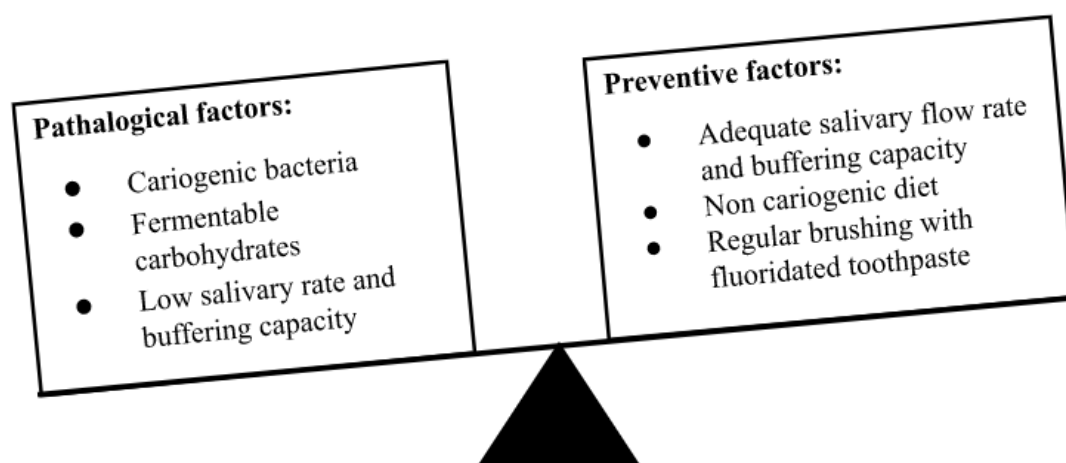


Figure 2: Balance between the pathological and preventive factors (30)

The pathogenic and preventive variables that affect the formation and development of tooth decay must be balanced. Pathogenic factors are the reasons for the formation of caries lesions. These include; repeated consumption of fermentable carbohydrates especially between meals, low salivary rate and buffering capacity, existence of cariogenic bacteria, inadequate oral hygiene habits etc. However, in the presence of preventive factors which are adequate salivary flow rate and buffering capacity, good oral hygiene, non-cariogenic diet etc., caries formation and advancement of preexisting caries lesions can be prevented (30,31).

Even though the development of biofilm is a significant factor in the beginning of caries, it is not a factor in itself. In addition, the caries formation requires the presence of a host (tooth), pellicle, and free sugars (25). In the availability of fermentable carbohydrates, primarily sucrose, these cariogenic microorganisms in the oral cavity cause demineralization (32).

According to a recent systematic review, children who are infected by *Streptococcus mutans* at a young age have a higher likelihood of experiencing caries. Proper oral hygiene and a non-cariogenic diet can reduce the chance of developing tooth decay (33).

Host factors

The vulnerability of the tooth to caries is increased by several variables. Reduced saliva production, immunological characteristics, the presence of enamel abnormalities, hypoplasia, immature enamel, tooth morphology, tooth-related genetic factors (size, surface, fissure, and fossa depth), and malocclusions are all personal risk factors for caries development (34).

The individual's primary line of defense against tooth decay is saliva. It not only cleans the teeth of food and microorganisms but also serves as a buffer against acid formation. It also serves as a storage place for the calcium and phosphate ions needed for the remineralization of enamel. A reduction in the buffering capacity brought on by the reduced saliva flow rate during sleeping

makes teeth more vulnerable to caries at this time (35). Innate and acquired defense factors in saliva provide protection by negatively affecting bacterial activity (36). Because of enamel's lack of immunological activity, immunoglobulin A (IgA), serum, and gingival crevicular fluid make up the majority of the immune response to *S. mutans*. Children who are exposed to oral bacteria produce salivary IgA antibodies (35).

The anatomy and position of the tooth play an important role in plaque accumulation on the tooth surface. These circumstances have a negative influence on the tooth surface's ability to be cleaned, making it difficult to remove dental plaque and triggering the start of demineralization (37).

Dental Plaque and Microorganisms

Biofilms are expressed as a community of microorganisms living in a gel-like layer in a polymeric structure that they produce, by adhering to a surface (38). Biofilm formation can be seen on living cells in vivo or on non-living surfaces in vitro. Biofilm formation is promoted by excessive moisture and the availability of nutrients in the environment. The creation and growth of biofilms are also influenced by a number of environmental parameters, including temperature, nutrition availability, pH, bacterial strain, and surface characteristics (39). Biofilms can be formed from a single or multiple microorganism species. In biofilms containing different species, each species forms its own micro colony. These micro colonies are separated by water channels. The water flow within these water channels allows the diffusion of nutrients and oxygen (40).

Dental plaque is one type of biofilm that goes through multiple phases to develop (41). Dental plaque is the buildup of bacteria, leukocytes, macrophages, dead epithelial cells, salivary glycoproteins, and occasionally food debris on the teeth. A thin pellicle layer made of glycoproteins typically covers the cementum and enamel surfaces of teeth. The source of this pellicle layer is saliva. It takes only a few minutes for this layer to develop again after being removed by mechanical means, and it actively contributes to bacterial adherence on the tooth surface. Cocci-shaped bacteria, a few epithelial cells, and neutrophils are the first structures to adhere to the pellicle. The plaque gradually turns into a complex structure with micro colonies formed by microorganisms that are not removed within the first few hours (42).

Adhesion of bacteria to the pellicle layer is the second stage of biofilm formation. Binding at this stage is reversible and bacteria can easily separate from the pellicle. Extracellular polysaccharide (EPS) synthesis starts after the bacteria attach to the pellicle layer, and the plaque steadily expands as more bacteria attach to the pellicle (43). Species belonging to the genera *Actinomyces*, *Streptococcus*, *Haemophilus*, *Capnocytophaga*, *Veillonella* and *Neisseria*

are the first bacteria to adhere to the tooth surface. Bacteria that will adhere to the tooth surface later, recognize the first colonized bacteria from the polysaccharide and protein receptors on the cell surfaces and attach to them. Bacteria that adhere later are *Fusobacterium nucleatum*, *Treponema spp*, *Tannerella forsythensis*, *Porphyromonas gingivalis*, *Aggregatibacter actinomycetemcomitans* species (44,45).

Bacteria that cause caries can also be present on the surfaces of healthy teeth. Yet, when caries-forming activities are minimal, this is not clinically significant (26). There is a synergistic relationship between the microorganisms normally found in the mouth and the host. Disruption of this relationship with various environmental factors can create negative effects for the host. These factors involve frequent intake of fermentable carbohydrates, decreased salivary flow rate, and poor oral hygiene (46,47). In the research, it has been observed that there are more *Streptococcus mutans* and *Streptococcus sobrinus* on the carious tooth surface compared to the healthy tooth. Lactobacilli were found in deeper caries lesions (47).

The most significant known cariogenic bacteria is *Streptococcus mutans*. The presence of acids released into the environment as a result of the fermentation of sucrose and other carbohydrates is necessary for *Streptococcus mutans* to adhere to the tooth surface (48). Another bacteria that frequently give rise to dental caries is *Lactobacillus casei*. This species grows in a wide pH range and generates an excessive amount of lactic acid. This bacteria adheres more easily to the tooth surface in the presence of *S. mutans* (49). A variety of *Bifidobacterium* species, *Actinomyces* species, *Propionibacterium* species, and *Scardovia wiggsiae* are among the bacteria that have been linked to caries in more recent investigation (25).

Diet

In the 1950s, the cause and effect relationship between caries formation and fermentable carbohydrate consumption was established and published in the scientific literature for the first time. The Vipeholm research emphasized the significance of sugar consumption frequency and the type of the sugar on caries development (50-53). There was no agreement among scientists on the connection between sugar intake and caries prior to this time (51).

The bacteria that are found in dental plaque metabolize the fermentable carbohydrates, convert them into organic acids that promote demineralization of the dentin and enamel layers. As sugars and other fermentable carbohydrates are turned into organic acids, the pH decreases. Around pH 5.5, the tooth's hard tissue starts to demineralize. After all these events, dental caries occur (54). All mono- and disaccharides can be used by bacteria in the oral flora to generate acid. Animal studies examining the impact of mono and disaccharides on dental caries have not revealed any information on any differences. It has been shown that early plaque-

forming bacteria consume lactose less than other carbohydrates, which results in reduced acid generation (55).

Sucrose, the most commonly consumed sugar in the daily diet, was highlighted in many research until recent years that focused on the connection between sugars and dental caries. Yet in modern industrialized nations, the daily diet consists of sugar mixtures consisting of sucrose, glucose, lactose, fructose, glucose syrups, high fructose corn syrups and other synthetic oligosaccharides and further processed starch (56).

Oral hygiene

Dental plaque is regarded as a significant risk factor for the emergence of caries in young children. According to several studies, a child's brushing routine, frequency, and use of fluoridated toothpaste are all related to the formation and progression of dental caries (57,59). Children are more prone to have cariogenic diets and are typically ignorant of the consequences of poor oral hygiene. In addition to that, parental neglect about the importance of oral hygiene aggravates this situation (60). It is advised that parents assist their children in brushing their teeth until they start school because young children are unable to do it on their own efficiently (61).

Socioeconomic status

In the protection of oral health, the social structure of the society and the level of education within this structure are taken into consideration. It has been demonstrated that the presence and severity of ECC in children are connected to the education level of the parents. Children from households with high levels of education were shown to have low caries prevalence and dmft-t scores (62).

Social class has a variety of effects on ECC risk. Low-income people have financial, social, and material challenges that jeopardize their opportunity to get professional oral health care and live in a healthy environment (63). According to reports, children from low-income households are more likely to have low birth weights and ECC (64). Furthermore, research has indicated that children from low-income households see the dentist for the first time at an older age, less frequently, and only when they are experiencing dental problems (65).

In another point of view, preschoolers' experience with caries has been proven to be highly influenced by the number of children in the household, the baby's birth weight, the age gap between siblings, and the mother's age at the time of delivery (66).

2.4. Classification of Caries Lesions

Classification of caries lesions is made according to the localization of the lesion, its progression, the virginity of the lesion, its extent, and the type of tissue affected (67).

2.4.1. According to localization

a) Smooth surface caries

Plaque retention on smooth surfaces is less than in pit fissures. It is usually seen at the gingival margin or at the approximal regions below the contact area (67).

b) Pit and fissure caries

Pits and fissures are areas of rapid bacterial colonization. Since the teeth are more prone to caries immediately after eruption, early fissure sealant applications are of great importance in preventing caries. Shape, depth and morphological differences of pits and fissures affect caries susceptibility (67).

c) Root caries

It is generally seen due to conditions such as gingival recession in older patients. Cement is structurally more prone to caries than enamel. It progresses rapidly and is difficult to restore (67).

2.4.2. According to progression

a) Acute caries

It is the type of caries generally seen in primary teeth. Acute caries lesions are lighter in color than other types. The lesion progresses rapidly, pulp exposure or hypersensitivity may be seen (67).

b) Chronic caries

Progress slowly. Depending on the progression rate of the caries, the pulp protects itself by producing reactive dentin (67).

c) Arrested caries

Caries that have stopped progressing are in this class. It can be seen in primary and permanent teeth. It is seen as a result of the change in the balance in the cariogenic oral environment with protective factors (67).

2.4.3. According to virginity of lesion

a) Primary caries

These are caries lesions seen on previously healthy dental tissue (67).

b) Secondary caries

These are caries lesions seen at the edges and under the restoration. It may occur due to microleakage seen in poorly adapted restorations (67).

c) Recurrent caries

It is seen in cases where the carious tissue is not completely removed while the tooth is being restored (67).

2.4.4. According to extend of caries

a) Incipient caries

The lesion has subsurface demineralization over a surface layer that appears to be intact. Such lesions have potential to remineralize, thus restorative treatment is not indicated (67).

b) Occult caries

These are caries lesions that cannot be seen in clinical examination but can be detected with a well-done radiograph (67).

c) Cavitation

2.4.5. According to tissue affected

a) Enamel Caries

Initial caries is the first evidence of caries activity in enamel. If the lesion of demineralized enamel does not reach the border of enamel and dentin and the enamel surface is quite hard and still intact, this lesion can be remineralized if oral hygiene is maintained (67).

b) Dentin Caries

The caries have extended to the dentin. Usually remineralization is not possible. Tooth preparation and restoration are indicated (67).

c) Cement Caries:

It is the caries formed on the root surface (67).

2.5. Diagnosis of Dental Caries

Early diagnosis and treatment of caries lesions reduces the loss of material due to caries, decreasing the cost and duration of the treatments to be performed. The caries diagnosis method used in routine examination is radiographic evaluation in addition to visual and tactile examination (68,69).

The features that the ideal caries diagnosis method should have are as follows (68,69):

- Should be able to diagnose caries even in its early stage
- Should give correct results
- Should be easy to apply
- Should be able to assess whether the lesion is active/inactive
- Should be able to diagnose all surfaces of the tooth
- Should be sensitive

2.5.1. Inspection and tactile examination

The clinical identification of caries is usually carried out by dentists doing a thorough visual and tactile examination of teeth after cleaning and air drying, which are the conventional diagnostic methods (70). The whole tooth surface is thoroughly examined utilizing a dental mirror, light, and probe (71-73).

On visual examination, white spot lesions, discolorations and cavitations can be diagnosed. When examined under light, initial carious lesions appear whiter and more opaque than healthy enamel tissue. This is due to increased porosity as a result of demineralization. Demineralization in dentin is seen as a shadow reflected under the intact enamel surface (69). During the clinical examination, the teeth are dried with compressed air spray and isolated with cotton pads. By examining the clinical appearance of the caries, the severity of the lesion is determined (70,74-76).

Probe and dental floss can be used for tactile examination. The use of a sharp ended probe may cause trauma to the enamel surface, may lead to cariogenic bacteria to be transferred to healthy teeth and cavitation of initial caries lesions, therefore not recommended (68,77).

2.5.2. Dental radiographs

In addition to inspection, dental radiographs are also beneficial especially in detecting proximal lesions, assessing the extent of the caries lesion, periodontal health, and association of the primary teeth with the permanent ones (25). Bone and dental hard tissues have a radiopaque appearance due to their calcified nature. Since soft tissues are less calcified than bone or teeth, they appear radiolucent (78). On radiographic examination, caries lesions are seen as areas of lower density than healthy tissues. This image shows the demineralization and destruction of dental hard tissues (79).

Clinical examinations alone might not be enough to diagnose caries in some patients. Certain carious lesions may go unnoticed during the clinical examination due to visual assessment

(80,81). *Daniels et al.* compared the detection of interface caries in high-risk children with clinical examination and radiography methods and calculated how many lesions were incorrectly identified. They concluded that to diagnose caries, a clinical examination alone was insufficient. Radiographic exams should be used to assist examinations (82).

In addition to the benefits of radiographic evaluation, there are also a number of disadvantages (83,84). 3D structures are transferred to 2D in radiographic examination. Therefore, buccolingual evaluation cannot be performed and a definite conclusion about the extent of periapical lesions cannot be obtained. Soft tissue evaluation cannot be performed. In order for the lesion to be detected on the radiography, the mineral loss in the hard tissue should be between 30-50%. Therefore, cortical bone resorptions and perforations may not be diagnosed in the early period. Distortions that may occur during imaging may cause misdiagnosis (85,86). There are also harms caused by radiation. Therefore, the specific requirements of each patient and factors such as clinical examination, risk group of the patients, age of the patient, and time of the last radiograph taken should be evaluated and decided while taking the radiography (25) (Table 1). Exposure settings are modified when taking radiographs for children. It is necessary to justify the risk-benefit ratio by imposing dosage limits that are suitable for the patient and maximizing protection by keeping the dose as low as is reasonably achievable (87).

Disadvantages of radiographic evaluation (69,88);

- In the radiographic image, the proximal surfaces overlap, making diagnosis difficult.
- Occlusal caries may not be diagnosed due to the overlapping of the tubercles.
- The depth of caries may not be accurately diagnosed.
- No difference can be seen between active and inactive lesions
- Does not provide information about the cause of the radiolucent area seen on the radiograph

The table provides a summary of the American Dental Association's (ADA) recommendations for radiographic assessment. The clinical evaluation's findings should be used to adapt these suggestions to each patient's unique needs. Radiation dose from dental radiographs is minimal. Nonetheless, the ALARA (As Low As Reasonably Achievable) principle should be taken into consideration while making the choice (89).

Table 1: Recommendations for prescribing dental radiographs (89)

	Patient Age and Dental Developmental Stage		
Type of Encounter	Child with Primary Dentition (prior to eruption of first permanent tooth)	Child with Transitional Dentition (after eruption of first permanent tooth)	Adolescent with Permanent Dentition (prior to eruption of third molars)
New Patient* being evaluated for oral diseases	Individualized radiographic exam consisting of selected periapical/occlusal views and/ or posterior bitewings if proximal surfaces cannot be visualized or probed. Patients without evidence of disease and with open proximal contacts may not require a radiographic exam at this time.	Individualized radiographic exam consisting of posterior bitewings with panoramic exam or posterior bitewings and selected periapical images.	Individualized radiographic exam consisting of posterior bitewings with panoramic exam or posterior bitewings and selected periapical images. A full mouth intraoral radiographic exam is preferred when the patient has clinical evidence of generalized oral disease or a history of extensive dental treatment.
Recall Patient* with clinical caries or at increased risk for caries.**	Posterior bitewing exam at 6-12 month intervals if proximal surfaces cannot be examined visually or with a probe.		

Recall Patient* with no clinical caries and not at increased risk for caries.**	Posterior bitewing exam at 12-24 month intervals if proximal surfaces cannot be examined visually or with a probe.	Posterior bitewing exam at 18-36 month intervals.
Patient (New and Recall) for monitoring of dento- facial growth and develop- ment, and/or assessment of dental/skeletal relationships.	Clinical judgment as to the need for and type of radiographic images for evaluation and/or monitoring of dentofacial growth and development or assessment of dental and skeletal relationships.	Clinical judgment as to the need for and type of radiographic images for evaluation and/or monitoring of dentofacial growth and development, or assessment of dental and skeletal relationships. Panoramic or periapical exam to assess developing third molars.
Patient with other circum- stances including, but not limited to, proposed or existing implants, other dental and craniofacial pathoses, restorative/ endodontic needs, treated periodontal disease and caries remineralization.	Clinical judgment as to need for and type of radiographic images for evaluation and/or monitoring in these conditions.	

* Clinical situations for which radiographs may be indicated include, but are not limited to:

A. Positive Historical Findings

1. Previous periodontal or endodontic treatment
2. History of pain or trauma
3. Familial history of dental anomalies
4. Postoperative evaluation of healing
5. Remineralization monitoring
6. Presence of implants, previous implant-related pathosis or evaluation for implant placement

B. Positive Clinical Signs/Symptoms

1. Clinical evidence of periodontal disease
2. Large or deep restorations
3. Deep carious lesions
4. Malposed or clinically impacted teeth
5. Swelling
6. Evidence of dental/facial trauma
7. Mobility of teeth
8. Sinus tract ("fistula")
9. Clinically suspected sinus pathosis
10. Growth abnormalities
11. Oral involvement in known or suspected systemic disease
12. Positive neurologic findings in the head and neck
13. Evidence of foreign objects
14. Pain and/or dysfunction of the temporomandibular joint
15. Facial asymmetry
16. Abutment teeth for fixed or removable partial prosthesis
17. Unexplained bleeding
18. Unexplained sensitivity of teeth
19. Unusual eruption, spacing or migration of teeth
20. Unusual tooth morphology, calcification or color
21. Unexplained absence of teeth
22. Clinical tooth erosion
23. Peri-implantitis

**** Factors increasing risk for caries may be assessed using the ADA Caries Risk Assessment forms (0–6 years of age and over 6 years of age).**

Periapical Radiographs

The entire tooth is visible in periapical radiographs (90). Periapical radiographs can be used for evaluation of root canal anatomy and periapical/furcal pathologies, examination of traumatized teeth, detection of internal and external resorptions (91).

Panoramic Radiographs

Panoramic images provide a comprehensive view of the maxilla and mandible (90). Panoramic radiographs may be preferred in extensive caries or when a large area needs to be examined. It is important for the image quality that the patient shows good cooperation and stands still during the shooting. Panoramic radiographs can be used in patients who cannot tolerate intraoral radiographs, in patients who have pain during intraoral radiographs due to acute periapical abscess or extraoral swelling, in trauma cases with suspected conditions such as condyle fractures, in cases where generalized dental anomalies are observed, and in patients with suspected formations such as cysts and tumors (91).

Anterior Occlusal Radiographs

In addition to the posterior teeth, the anterior incisors in the upper jaw are among the teeth most affected by caries. One of the most important reasons for this is the child's eating habits. Long-term bottle feeding and frequent consumption of sugar-containing foods during feeding cause cavities. Anterior occlusal radiographs are used to diagnose and determine the depth of caries seen in this region (92).

Bitewing radiographs

Bitewing radiographs can be used to diagnose caries at the proximal and occlusal surfaces of the teeth and to determine the depth of the lesion. In addition, these radiographs can be used to evaluate secondary caries and to examine the adaptation and marginal fit of restorations (91). In cases when the proximal surfaces of the teeth cannot be inspected visually or by probing, the American Academy of Pediatric Dentistry (AAPD) advises obtaining posterior bitewing radiographs on every patient and at periods of 6 to 12 months (93).

To summarize in general, the indications for dental radiographs in children are schematized in the table, according to the guideline published by EAPD (European Academy of Pediatric Dentistry) in 2019 (Table 2) (91).

Table 2: Indications of dental radiographs in children and adolescents (+indicated, ±may have some indication, – no indication) (91)

	Bitewing radiograph	Periapical radiographs	Panoramic X-rays
Caries detection and diagnosis	Method of 1st choice	+	2nd line: bitewing PR
(Acute) Dental infection	–	+	+
Dental Trauma			
Tooth fractures and luxation injuries	–	Method of 1st choice	–
Severe dental trauma: multiple fractured teeth, crown-root fractures, mobile fragments etc.	–	Method of 1st choice	–
Complication: tooth resorption	–	Method of 1st choice	–
Dental anomalies			
Hypodontia	–	Method of 1st choice, when localized	Method of 1st choice, when generalized
Supernumerary teeth	–	Method of 1st choice, when localized	Method of 1st choice, when generalized
Suspected tooth impaction	–	Method of 1st choice, when localized	Method of 1st choice, when generalized
Developmental disorders			

Molar-incisor hypomineralisation	–	Method of 1st choice, when one severely affected molar	Method of 1st choice, when >1 severely affected molar
Amelo-/Dentino-/Osteogenesis imperfecta	–	+	Method of 1st choice
Cleft lip and palate patients	–	+ or maxillary occlusal projection	+
Pathological findings			
Periodontal disease	±	Method of 1st choice, when localized	Method of 1st choice, when generalized
Condylar morphology in patients with temporomandibular dysfunction	–	–	+
Cysts and benign tumors	–	–	–+
Invasive cervical resorption	–	+	–

2.5.3. Recent methods for diagnosis of dental caries

- Transillumination Methods
 - Fibre Optic Transillumination Method (FOTI)
 - Digital Fiber Optic Transillumination Imaging Method (DI-FOTI)
 - Near Infrared Transillumination Method (NILT)
- Optical Coherence Tomography
- Electrical Conductivity Measurements
- Ultrasonic Imaging System
- Fluorescent Techniques (Laser Fluorescence Method)

- Camera and Fluorescent Technique Combination (Quantitative Light Fluorescence (QLF)) (94)

2.5.4. Developing methods for diagnosis of dental caries

- Canary System (Photothermal Radiometry and Modulated Luminescence Technique)
- Terahertz imaging
- Multiphoton Imaging Microscope
- Fluorescence Spectroscopy
- Soprolife / Soprocure / Soproimaging
- Raman Spectroscopy
- Confocal Laser Scanning Microscope (95)

International Caries Detection and Assessment System (ICDAS)

A useful tool for identifying and documenting caries is the International Caries Detection and Assessment System (ICDAS). A higher score corresponds to a more severe lesion according to the ICDAS, which divides caries lesions into six categories with scores that vary from 0 to 6. The ICDAS can monitor the alterations and development of caries lesions (96).

For the purpose of assessing caries in connection with restorations and sealants, this approach was modified in 2005 (ICDAS II). With this approach, early carious lesions are detected by doing a visual analysis of the teeth after being cleaned and dried. The ICDAS II code system comprises two numbers; the first number is used for sealants and dental restorations, and its coding varies from 0 to 9 (Table 3). The second number used coding varies from 0 to 6 to analyze caries and identify initial non-cavitated enamel lesions that are seen following drying the tooth surface (Table 4) (96-100).

Table 3: First digit code of ICDAS II (101,102)

Code	Visual examination
0	Surface not restored or sealed.
1	Sealant, partial.
2	Sealant, full.
3	Tooth colored restoration.
4	Amalgam restoration.

5	Stainless steel crowns.
6	Porcelain or gold or PFM crown or veneer.
7	Lost or broken restoration.
8	Temporary restoration.
9 Used for the following conditions:	
96	Tooth surface cannot be examined.
97	Tooth missing because of caries.
98	Tooth missing for reasons other than caries.
99	Unerupted.

Table 4: Second digit code of ICDAS II (101,102)

Code	Visual Examination
0	Sound tooth surface: no evidence of caries after prolonged air drying (5 s)
1	First visual change in enamel: opacity or discoloration (white or brown) is visible at the entrance to the pit or fissure after prolonged air drying, which is not or hardly seen on a wet surface
2	Distinct visual change in enamel: opacity or discoloration distinctly visible at the entrance to the pit and fissure when wet, lesion must still be visible when dry
3	Localized enamel breakdown due to caries with no visible dentine or underlying shadow: opacity or discoloration wider than the natural fissure/fossa when wet and after prolonged air drying
4	Underlying dark shadow from dentine+/- localized enamel breakdown
5	Distinct cavity with visible dentine: visual evidence of demineralization and

	dentine exposed
6	Extensive distinct cavity with visible dentine and more than half of the surface involved

2.6. Caries Risk Assessment

Calculating the possibility of the development of new caries within a specific time period or the progression of preexisting caries lesions is called caries risk assessment (103,104). Evaluation of a pediatric patient's caries risk and developing an individualized treatment plan with the information gathered from caries risk assessment is essential for effective treatment of dental caries (105-109).

Caries risk assessment involves detecting various markers associated with the progression of new caries lesions and creating a comprehensive treatment plan that is preventative, customized and noninvasive (110).

Insufficient salivary flow rate, repeated consumption of fermentable carbohydrates, orthodontic/ prosthetic appliances, noticeable dental plaque, certain medical conditions, and cariogenic biofilm are some of the parameters used while assessing caries risk factors (111). Also, many studies have demonstrated that the existence of one or more cavitated/non cavitated caries lesions is a powerful predictor of the likelihood of developing caries. Due to the fact that dental restorations do not have a direct or indirect effect on caries formation, but show the existence of the factors that trigger the process, they are seen as risk indicators. Besides these listed above, there are some protective factors that prevent/stop caries formation which include drinking optimally fluoridated water, regularly visiting a dental office, using an age-appropriate, fluoridated toothpaste and having fluoride varnish applied regularly (111,112). On the other hand, social factors that influence health have demonstrated a prognostic value in the event of caries formation and can be seen as environmental variables. Low health literacy of parents, being unable to access dental treatment, and low-income levels are counted as environmental factors (107).

Intensive prophylactic treatment plans are necessary for pediatric patients who are in the high caries-risk group to stop the progression of caries and their onset. In addition to the benefits of the preventive treatments to the patients who are in the high-risk group, the patients who are in the low-risk group for dental caries can also take advantage of such treatments (113).

There are numerous articles on caries risk assessment as a result of research that have been carried out for many years (114-117).

The American Academy of Pediatric Dentistry has revealed Caries Risk Assessment forms which were created by a team of specialists for those aged between 0 to 5 years (Table 5) and 6 years or older (Table 6). Patients are categorized as high, moderate, and low risk after being evaluated clinically. In addition, risk factors and protective measures are taken into consideration during this assessment process (118,119).

Table 5: Caries-risk Assessment Form for 0-5 Years Old (118)

Factors	High risk	Moderate risk	Low risk
Risk factors, social/behavioral/medical • Mother/primary caregiver has active dental caries • Parent/caregiver has life-time of poverty, low health literacy • Child has frequent exposure (> 3 times/day) between-meal sugar-containing snacks or beverages per day • Child uses bottle or non-spill cup containing natural or added sugar frequently, between meals and/or at bedtime • Child is a recent immigrant • Child has special health care needs^a	Yes Yes Yes Yes	Yes Yes	
Risk factors, clinical • Child has visible plaque on teeth • Child presents with dental enamel defects	Yes Yes		
Protective factors • Child receives optimally-fluoridated drinking water or fluoride supplements			Yes Yes

• Child has teeth brushed daily with fluoridated toothpaste • Child receives topical fluoride from health professional • Child has dental home/regular dental care			Yes Yes
Disease indicators^β • Child has non-cavitated (incipient/white spot) caries lesions • Child has visible caries lesions • Child has recent restorations or missing teeth due to caries	Yes Yes Yes		

^α Practitioners may choose a different risk level based on specific medical diagnosis and unique circumstances, especially conditions that affect motor coordination or cooperation.

^β While these do not cause caries directly or indirectly, they indicate the presence of factors that do.

Instructions: Circle YES that corresponds with those conditions applying to a specific patient. Use the circled responses to visualize the balance among risk factors, protective factors, and disease indicators. Use this balance or imbalance, together with clinical judgment, to assign a caries risk level of low, moderate, or high based on the preponderance of factors for the individual. Clinical judgment may justify the weighting of one factor (e.g., heavy plaque on the teeth) more than others.

Overall assessment of the child's dental caries risk:

High: ☐ Moderate: ☐ Low: ☐

Table 6: Caries-risk Assessment Form for ≥ 6 Years Old (118)

Factors	High risk	Moderate risk	Low risk
Risk factors, social/behavioral/medical • Patient has life-time of poverty, low health literacy	Yes Yes		

• Patient has frequent exposure (> 3 times/day) between-meal sugar-containing snacks or beverages per day • Child is a recent immigrant • Patient uses hyposalivatory medication(s) • Patient has special health care needs^a		Yes Yes Yes	
Risk factors, clinical • Patient has low salivary flow • Patient has visible plaque on teeth • Patient presents with dental enamel defects • Patient wears an intraoral appliance • Patient has defective restorations	Yes Yes Yes	Yes Yes	
Protective factors • Patient receives optimally-fluoridated drinking water • Patient has teeth brushed daily with fluoridated toothpaste • Patient receives topical fluoride from health professional • Patient has dental home/regular dental care			Yes Yes Yes Yes
Disease indicators ^B • Patient has interproximal caries lesion(s) • Patient has new non-cavitated (white spot) caries lesions • Patient has new cavitated caries lesions or lesions into dentin radiographically • Patient has restorations that were placed in the last 3 years (new patient) or in the last 12 months (patient of record)	Yes Yes Yes Yes		
^a Practitioners may choose a different risk level based on specific medical diagnosis and unique circumstances, especially conditions that affect motor coordination or cooperation.			

^B While these do not cause caries directly or indirectly, they indicate presence of factors that do.

Instructions: Circle YES that corresponds with those conditions that apply to a specific patient. Use the circled responses to visualize the balance among risk factors, protective factors, and disease indicators. Use this balance or imbalance, together with clinical judgment, to assign a caries risk level of low, moderate, or high based on the preponderance of factors for the individual. Clinical judgment may justify the weighting of one factor (e.g., heavy plaque on the teeth more than others).

Overall assessment of the dental caries risk:

High: ☐

Moderate: ☐

Low: ☐

Preparing treatment plans depending on patients' age and risk factors enables dentists to provide personalized care and provide a higher chance of success with lower complication rates. For this reason, the AAPD has summarized the treatment of carious teeth in children aged 0-5 (Table 7) and children over 6 years old (Table 8) according to risk groups in the tables (120).

Table 7: Example of Caries Management Pathways for 0-5 Years Old (121)

Risk category	Diagnostics	Preventive interventions			Restorative interventions
		Fluoride	Dietary counseling	Sealants	
Low risk	Recall every six to 12 months Radiographs every 12 to 24 months	Drink optimally-fluoridated water Twice daily brushing with fluoridated toothpaste	Yes	Yes	Surveillance
Moderate risk	Recall every six months Radiographs every six to 12 months	Drink optimally-fluoridated water (alternatively, take fluoride supplements with fluoride-deficient water supplies)	Yes	Yes	Active surveillance of non-cavitated (white spot) caries lesions

		Twice daily brushing with fluoridated toothpaste Professional topical treatment every three months			Restore cavitated or enlarging caries lesions
High risk	Recall every three months Radiographs every six months	Drink optimally-fluoridated water (alternatively, take fluoride supplements with fluoride-deficient water supplies) Twice daily brushing with fluoridated toothpaste Professional topical treatment every three months Silver diamine fluoride on cavitated lesions	Yes	Yes	Active surveillance of non-cavitated (white spot) caries lesions Restore cavitated or enlarging caries lesions Interim therapeutic restorations (ITR) may be used until permanent restorations can be placed

Notes for caries management pathways table:

Twice daily brushing: Parental supervision of a “smear” amount of fluoridated toothpaste for children under age three, pea-size amount for children ages three through five.

Surveillance: Periodic monitoring for signs of caries progression; active surveillance: active measures by parents and oral health professionals to reduce cariogenic environment and monitor possible caries progression.

Silver diamine fluoride: Use of 38 percent silver diamine fluoride to assist in arresting caries lesions; informed consent: particularly highlighting expected staining of treated lesions.

Sealants: The decision to seal primary and permanent molars should account for both the individual-level and tooth-level risks.

Table 8: Example of Caries Management Pathways for >6-Years -Old (121)

Risk category	Diagnostics	Preventive interventions			Restorative interventions
		Fluoride	Dietary counseling	Sealants	
Low risk	Recall every six to 12 months Radiographs every 12 to 24 months	Drink optimally-fluoridated water Twice daily brushing with fluoridated toothpaste	Yes	Yes	Surveillance
Mode rate risk	Recall every six months Radiographs every six to 12 months	Drink optimally-fluoridated water (alternatively, take fluoride supplements with fluoride-deficient water supplies) Twice daily brushing with fluoridated toothpaste Professional topical	Yes	Yes	Active surveillance of non-cavitated (white spot) caries lesions Restore cavitated or enlarging caries lesions

		treatment every six months			
High risk	Recall every three months Radiographs every six months	Drink optimally-fluoridated water (alternatively, take fluoride supplements with fluoride-deficient water supplies) Brushing with 0.5 percent fluoride gel/paste Professional topical treatment every three months Silver diamine fluoride on cavitated lesions	Yes	Yes	Active surveillance of non-cavitated (white spot) caries lesions Restore cavitated or enlarging caries lesions Interim therapeutic restorations (ITR) may be used until permanent restorations can be placed
Notes for caries management pathways table: Twice daily brushing: Parental supervision of a pea-sized amount of fluoridated toothpaste for children six years of age. Surveillance: Periodic monitoring for signs of caries progression; active surveillance: active measures by parents and oral health professionals to reduce cariogenic environment and monitor possible caries progression.					

Silver diamine fluoride: Use of 38 percent silver diamine fluoride to assist in arresting caries lesions; informed consent: particularly highlighting expected staining of treated lesions.

Sealants: Although studies report an unfavorable cost/benefit ratio for sealant placement in low caries-risk children, expert opinion favors sealants in permanent teeth of low-risk children based on possible changes in risk over time and differences in tooth anatomy. The decision to seal primary and permanent molars should account for both the individual-level and tooth-level risks.

Another example of caries risk assessment form was carried out by International Association of Pediatric Dentistry (IAPD) which includes; caries risk indicators, diagnostic procedures, preventive therapy and restorative therapy recommendations (Table 9) (113).

Table 9: Dental Caries Care Pathways Based on a Child's Caries Risk Assessment (113)

Dental Caries Care Pathways Based on a Child's Caries Risk Assessment			
	Low Risk	Moderate Risk	High Risk
Caries Risk Indicators	Child has no caries No new lesions in 1 year No white spot lesions High SES	Child has/had 1 or more lesions 1 or more lesions/year Infrequent white spot lesions Middle SES	Child has/had 1 or more proximal lesions More than 2 new lesions/year Numerous white spot lesions Mother/caregiver has active caries Low SES
Diagnostic Procedures	Exam interval 12 months Radiograph interval	Exam interval 6 months Radiograph interval 6-12 months	Exam interval 3 months Radiograph interval 6 months Diet analysis
Preventive Therapy	Brushing with F toothpaste twice	Brushing with F toothpaste twice daily	Brushing with F toothpaste twice daily

	daily Sealants	Professional topical fluorides tx every 6 months Sealants	Systemic fluoride supplements** Professional topical fluoride tx every 3 months Sealants Brushing with high potency F gel (over age 6) Dietary counseling
Restorative Therapy	None	Active surveillance of white spot and enamel proximal lesions enamel proximal lesions Restoration or SDF*** tx. of progressing lesions Restoration or SDF tx. of cavitated lesions	Active surveillance white spot lesions Restoration of enamel proximal lesions Restoration or SDF tx. of progressing lesions Restoration or SDF tx. of cavitated lesions
* SES = socioeconomic setting ** Age and water supply considerations *** SDF = silver diamine fluoride topical treatment			

Another system used to evaluate caries risk is Cariogram. A computer software that can be used online allows for a caries risk assessment based on a variety of clinical findings, preventative measures, and risk factors (122). The patients are categorized as low, moderate, or high risk based on an algorithm. It assess nine parameters which are (Table 10) (123);

- Caries experience
- Related disease
- Diet content
- Diet frequency
- Plaque quantity
- *Streptococcus mutans* level

- Fluoride program
- Salivary secretion
- Saliva buffer capacity

Table 10: Caries related factors and the data needed to create a Cariogram (123)

Factor*	Comment	Info/data needed
Caries experience	Past caries experience, including cavities, fillings and missing teeth because of caries. Several new cavities definitely appearing during preceding year should give a high score even if number of fillings is low	DMFT DMFS New caries experience in the past 1 year
Related diseases	General disease or conditions associated with dental caries	Medical history Medications
Diet, contents	Estimation of the cariogenicity of the food, in particular sugar contents	Diet history Lactobacillus test count
Diet, frequency	Estimation of number of meals and snacks per day, mean for 'normal days'	Questionnaire results 24 h recall or dietary recall (3 days)
Plaque amount	Estimation of hygiene, for example according to Silness-Loe Plaque Index (PI). Crowded teeth leading to difficulties in removing plaque interproximally should be taken into account	Plaque index
Mutans streptococci	Estimation of levels of mutans	Strip mutans test or other

	streptococci (Streptococcus mutans, Streptococcus sobrinus) in saliva, for example using Strip mutans test	laboratory tests giving comparable results
Fluoride programme	Estimation of to what extent fluoride is available in the oral cavity over the coming period of time	Fluoride exposure Interview patient
Saliva secretion	Estimation of amount of saliva, for example using paraffin-stimulated secretion and expressing results as milliliter saliva per minute	Stimulated saliva test – secretion rate
Saliva buffer capacity	Estimation of capacity of saliva to buffer acids, for example using the Dentobuff test	Dentobuff test or other laboratory tests giving comparable results
*For each factor, the examiner has to gather information by interviewing and examining the patient, including some saliva tests. The information is then given a score of a scale ranging from 0 to 3 (0–2 for some factors) according to predetermined criteria. The score ‘0’ is the most favorable value and the maximum score ‘3’ (or ‘2’) indicates a high, unfavorable risk value.		

With the Cariogram program, the data is prepared in the form of a pie chart. In this graphic; (Figure 3) (124)

- ‘Diet’ related data are shown in dark blue,
- ‘Bacteria’ related data are shown in red,
- ‘Susceptibility’ related data are shown in light blue,
- ‘Circumstances’ related data are shown in yellow,
- and ‘Chances of avoiding caries’ related data are shown in green.

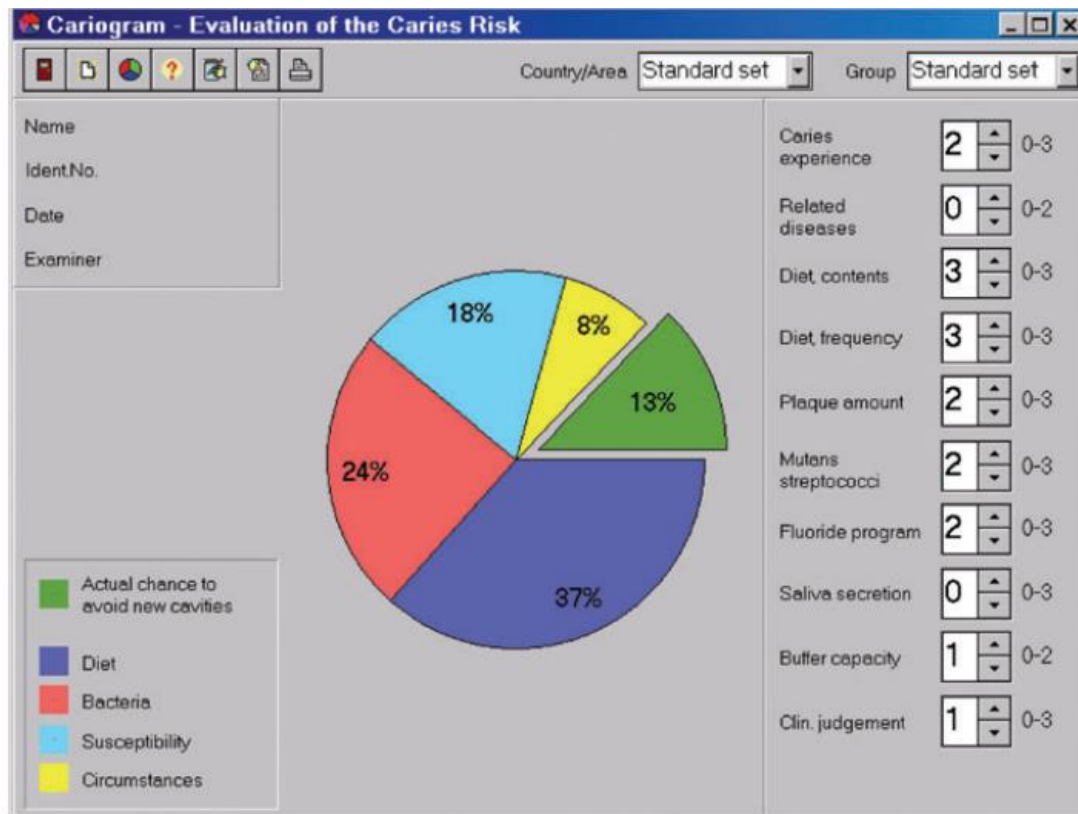


Figure 3: Example of a Cariogram indicating high caries risk with the ‘chance of avoiding new cavities’ estimated to only 13%. (124)

2.6.1. Early Childhood Caries (ECC)

Early childhood caries (ECC) was once known as infant bottle tooth decay and now is a term used to identify the condition when a patient under the age of six has one or more decayed, missing, or filled primary tooth (125).

Severe early childhood caries (S-ECC) is a term used to define the condition when (125);

- A child who is younger than three years of age, has a smooth surface caries lesion.
- A child aged between three to five years has one or more decayed, missing or filled (dmf) maxillary anterior teeth.
- A three years old child has a dmf score ≥ 4 , a four years old child has a dmf score ≥ 5 and a five years old child has a dmf score ≥ 6

Early childhood caries prevalence has been estimated to range from 1% to 12% in developed countries, but it may reach 70% in high-risk populations, such as poor socioeconomic groups or racial or ethnic minorities (126).

As in the other types of caries, ECC is a result of bacterial activity after metabolizing fermentable carbohydrates which leads to the demineralization of dental hard tissue (127). After

a short time following the eruption of the teeth, the disease causes quick and extensive destruction. First affecting the maxillary incisors, ECC later progresses to the molars (128).

Vertical and horizontal transmissions are the two ways that Mutans Streptococci (MS) and Lactobacillus species' colonization, which play an important role in caries formation in the pediatric population (129). The caregiver may transfer these bacteria via salivary interaction. This pathway is called vertical transmission. This bacterial transmission is called horizontal when it happens between daycare children or other family members (130).

Excessive sugar consumption is a risk factor for developing ECC (131). The risk for caries formation is elevated due to nocturnal bottle feeding, repeated consumption of foods and liquids containing sugar between meals, frequent use of spill proof cups (132). Advantages of nursing during the first year of life are well known (133). However, frequent and night time breastfeeding and bottle use after that point, are the main causes of ECC seen in children.¹³⁴ Caregivers should prevent children under the age of two, from consuming foods and beverages that contain sugar, according to American Heart Association's (AHA) recommendations (135). ECC has a significant negative influence on children's and their families life satisfaction by causing persistent discomfort as a result of infection and pain, and is also an excessive financial burden on society (136). Frequent hospitalization (137,138), increased newly formed caries lesions (139,140), missed school days are the other outcomes of untreated early childhood caries (141).

The possibility of experiencing pain and discomfort due to a decayed tooth, is not directly associated with the size of the caries lesion. As a result of extensive caries with pulpal involvement, sepsis may occur. This situation may have some severe systemic considerations such as spreading the localized infection to the body and more infrequently, death (142).

Most of the patients suffering from ECCs needed to be treated under general anesthesia or sedation, which is the main reason for potential health related risks (143) and expensive treatment costs. There is also a risk for recurring the caries lesions after treatment. Therefore, prevention of the caries formation and stopping the progression are two key points which are as important as treating the decayed teeth (144).

The latest ECC treatment strategy emphasizes primary prevention (145). The American Academy of Paediatric Dentistry (AAPD) recommends that children should get a dental examination before their first birthdays and suggests determining the likelihood of developing caries starting at age 6 months and giving caregivers guidance on how to avoid dental caries (146). There are several preventive pathways such as brushing teeth with an age appropriate fluoridated toothpaste twice a day and regular fluoride varnish application to lessen the

occurrence rates of ECCs. Home care is important since the eruption of the first tooth and also to prevent demineralized dental hard tissue from turning into cavitated lesions. Such lesions may affect pulp tissue if left untreated. Advanced infections caused by affected dental pulp may give rise to antibiotic use among pediatric patients and hospitalization cases. Early extraction of the affected tooth is also a result of these infections (147). Even though there is a risk of developing fluorosis due to consumption of excessive fluoride, with the right amount, the benefits of this ingredient to prevent caries formation is higher. For the children under three years of age, a rice sized amount of toothpaste is recommended which contains approximately 0.1 milligram [mg] fluoride. For patients between three to six years of age, a pea sized amount of fluoridated toothpaste which contains approximately 0.25 mg fluoride is sufficient to prevent caries formation (148). An appropriate sized toothbrush for the age and needs of the patient should be chosen while brushing. Parents or caregivers should be advised to help the children who cannot efficiently brush their teeth. After brushing, rinsing the whole toothpaste should be avoided to optimize the fluoride's positive effects (149). The occurrence rate of caries is significantly influenced by how frequently children brushed their teeth and how difficult it was for them to do so throughout the preschool years (150).

Children under the age of six who are at risk for ECC should have a professional application of 5% sodium fluoride varnish (NaFV; 22,500 parts per million F) which is an effective way in lowering the occurrence of ECC (151,152). Moreover, to stop the advancement of cavitated caries lesions administration of 38 percent silver diamine fluoride (SDF) to the decayed primary teeth is an efficacious way of treating ECC (153,154).

Treatment of ECC lesions is important to primary teeth until the eruption of permanent teeth. For the pediatric patients suffering from ECC, when the final restorations cannot be implemented due to various reasons, temporary treatment of decayed teeth can be done by using interim therapeutic restoration technique or the use of silver diamine fluoride (SDF) (155). In cases when these minimal invasive methods are inadequate while treating decayed teeth, stainless steel crowns (SSC) may be the treatment of choice for teeth with extensive and multi surface caries lesions. This treatment option needs less retreatment due to secondary caries (156).

2.6.2. Molar Incisor Hypomineralization (MIH)

Molar incisor hypomineralization is a developmental abnormality that creates clinical and esthetic issues due to extreme sensitivity, the possibility of post-eruptive destruction of the tooth structure, atypical caries formation, and adhesion difficulties of resin-based restorative

materials. This abnormality may affect one or more permanent first molars as well as permanent incisors (157,158). Extent and the complexity of the lesion and chances of post eruptive destruction, the degree of hypersensitivity, age and desires of the patients are the criteria that should be evaluated while making a proper treatment plan (158,159).

Studies carried out in European nations have revealed that the prevalence of MIH patients ranges from 3.6% to 25% (160). The incidence of MIH patients globally ranged from 2.9% to 44%, according to later investigations. Due to the use of different indexes and diagnostic criteria, and age groups in the studies, it is challenging to compare the research in this area. In our country, investigations done in Istanbul revealed a 9.1–14.9% incidence of MIH. There was no difference between the sexes when the prevalence of MIH was looked at by gender (161,162).

The earliest research was conducted in Sweden in the late 1970s, and it was hypothesized that specific conditions that arise during enamel development may contribute to the development of this abnormality (163). According to the literature, a single nomenclature that does not identify any potential etiological conditions should be used when referring to these developing enamel abnormalities. In order to define the systemic hypomineralization of one or more of the four permanent first molars, occasionally also including incisors, the name MIH has been developed. This definition was chosen to emphasize that the molars are always affected and frequently involve incisors (164,165).

Etiology

According to research on the etiological reasons, it has been found that a combination of hereditary and systemic variables might result in hypomineralization. The exposure period, timing, and potency all affect how these systemic and genetic variables influence the extent and severity of the abnormality (166).

Ameloblasts secrete a tissue known as enamel as a result of their activity. After the enamel matrix has been preserved long enough to achieve its full thickness, hypomineralization is assumed to take place. Ameloblasts can be easily injured in this process. Due to poor resorptive potential and proteolytic enzyme suppression, these cells induce protein retention (particularly amelogenin) when they are unable to finish their maturation, which results in hypomineralization over the full thickness of the enamel (167). Normal apatite deposition and crystal development are also dependent on the pH change that occurs during mineralization. Theoretically, circumstances that influence the pH of the matrix throughout enamel formation can result in MIH. Moreover, the production of hypomineralized enamel may be influenced by the absence of calcium phosphate, an increase in carbon concentration, and a reduction in

calcium phosphorus concentration (168). Research indicates that systemic etiological factors may contribute to these conditions (164).

The period from the end of pregnancy to the age of four years corresponds to the development phase of the ameloblasts of the maxillary and mandibular anterior teeth and first permanent molars. Therefore, studies of etiology have concentrated on the period between birth and early childhood and the etiological factors can be examined as prenatal, perinatal and postnatal. (169) *Garot et al.* (2022) comprehensively evaluated the causes of MIH. As a result of this systematic review and meta-analysis, it was found that MIH is linked to a number of systemic, genetic, and/or epigenetic variables that interact either simultaneously or additively, indicating a complex etiology. Prenatal aetiological variables are less likely to enhance the risk of MIH than peri- and postnatal aetiological factors (170).

a) Genetics

A single nucleotide polymorphism (SNP) is a variation of a single base pair in the human genome and can be a factor in some diseases. In some studies conducted in this direction, SNP in individuals with and without MIH has been investigated (171,172).

Kühnisch et al. (2013) examined the link between potential genetic loci and MIH. There were 2,013,491 SNPs in total that could be examined. A potential MIH locus, Rs13058467, was discovered on chromosome 22 ($p = 3.72E-7$), close to the SCUBE1 gene (173).

Jeremias et al. (2016) thoroughly examined the genetic factors that may be relevant to the development of MIH. They came to the conclusion that the probability to develop MIH was correlated with changes in amelogenesis-related genes (especially AMELX gene (Xq22)). (172) In a mouse model, the SCUBE1 gene was discovered to be localized to the dental papilla of both incisor and molar teeth (174).

Hočevár et al. (2020) investigated for proof of potential correlations between several hereditary variables that may have an impact on molar-incisor hypomineralization formation. The results indicated that MIH susceptibility may be significantly influenced by genetic variations in amelogenesis-related genes (SNP rs2245803 in the homozygous recessive variant of the MMP20 gene) (175).

b) Systemic factors and antibiotic use

There has been several research carried out in order to pinpoint the cause of MIH. Some of the potential causes of MIH include asthma, pneumonia, upper respiratory tract infections, otitis media, antibiotics, tonsillitis and tonsillectomy, and infantile rash with fever (176). In a study of children with MIH, asthma, bronchitis, pneumonia, and upper respiratory tract infections were present in 67% of the patients (177).

When *Lygidakis et al.* (2008) looked at the relationship between the mother's health during the last trimester of pregnancy and the health of the child and MIH, they found that 19.3% of patients had maternal prenatal problems, 44.3% had perinatal problems, and 21.9% had neonatal problems. Of the 14.5% of patients with MIH, the defect could not be linked to any disease (178).

de Souza et al. (2016) aimed to investigate the use of amoxicillin during early childhood and its association with molar incisor hypomineralization. The findings indicated that amoxicillin interferes with the early phases of amelogenesis by altering the ameloblasts' structural makeup and reducing the enamel matrix (179).

Fatturi et al. (2019) examined the systemic factors linked to MIH. Stress and maternal diseases during pregnancy were found to be strongly linked to an increased risk of MIH. Also, MIH incidence was connected to cesarean sections and delivery problems throughout the perinatal period. Only fever and respiratory problems were related to a greater occurrence rate of MIH in the postnatal period as a result of this systematic review and meta-analysis. However, very low quality was attributed to the evidence (180).

c) Premature birth

Premature birth has been associated with an increased prevalence of enamel defects, including permanent dentition hypoplasia and hypomineralization. *Aine et al.* (2000) conducted a study to measure the incidence of enamel abnormalities in the same preterm children's primary and permanent dentitions and to clarify the function of early dietary mineral and vitamin D consumption in the pathogenesis of enamel defects. They came to the conclusion that enamel abnormalities were more common in both the primary and permanent dentitions in preterm infants than in controls (181). With a decrease in gestational age and birth weight, enamel abnormalities become more severe (182).

d) Malnutrition

Studies have noted that enamel abnormalities may result from hypocalcemia seen in malnutrition brought on by low vitamin D and calcium intake, as well as in gastrointestinal diseases such diarrhea when intestinal absorption is compromised (183). According to reports, malnutrition brought on by insufficient calorie, protein, and vitamin intake, diarrhea accompanied by a fever and infection, or malnutrition brought on by a loss of appetite during the disease period may disturb calcium homeostasis and electrolyte balance and result in enamel defects (184).

Beentjes et al. (2002) examined the elements that contribute to MIH formation. As a result of the questionnaire both MIH and control groups' birth weights and lengths, as well as the length

of breast- and/or bottle-feeding and the frequency of problems during pregnancy and delivery, were similar. They observed no significant differences between the control group and the MIH group in terms of gastrointestinal or nutritional issues (185).

Diagnosis

To find out if MIH is present, the permanent first molars and incisors should be examined. After cleaning the teeth, evaluation should be performed by observing the dried tooth surface. The ideal age for examination is 8 years old (161).

Presence or absence of limited opacity: MIH is characterized by limited and often recessed defects that involve changes in enamel translucency. There may be a change in color to white, yellow, or brown. Enamel with a defect has a normal thickness and a smooth surface. The incisive or tubercle third of the crown is typically the area with opacities (165,186).

Post-eruptive breakdown: Post-eruptive breakdown (PEB) is the loss of the original shape of the enamel surface following tooth eruption. Limited pre-existing opacities are related to this loss (165).

Atypical restoration: When atypical restorations are assessed, they extend to the buccal or palatal flat surfaces of molar teeth. Around the borders of the restorations, opaque spots are commonly seen. Restorations on the buccal surface of the incisors that are unrelated to traumatic injuries can be seen (165).

Possible extractions carried out as a result of MIH: In mouths where it is believed that lost molar teeth are the result of MIH, opacities or unusual restorations in other permanent first molar teeth are notable. Opacities with distinct edges in the incisors might also be detected in situations when permanent molar teeth are absent. Due to MIH, incisor extraction is infrequently done (186,187).

The clinical signs and symptoms that should be considered for the MIH diagnosis are listed by EAPD in the table (Table 11)(166).

Table 11: The clinical signs and symptoms for MIH (166)

Diagnostic feature	Description of the defect
Teeth involved	● One to all four permanent first molars (FPM) with enamel hypomineralisation ● Simultaneously, the permanent incisors can be affected ● At least one FPM has to be affected for a diagnosis

	of MIH • The more affected the molars, the more incisors involved and the more severe the defects • The defects may also be seen at the second primary molars, premolars, second permanent molars and the tip of the canines
Demarcated opacities	• Clearly demarcated opacities presenting with an alteration in the translucency of the enamel • Variability in colour, size and shape • White, creamy or yellow to brownish colour • Only defects greater than 1 mm should be considered
Post-eruptive enamel breakdown	• Severely affected enamel breaks down following tooth eruption, due to masticatory forces • Loss of the initially formed surface and variable degree of porosity of the remaining hypomineralized areas • The loss is often associated with a pre-existing demarcated opacity • Areas of exposed dentine and subsequent caries development
Sensitivity	• Affected teeth frequently reveal sensitivity, ranging from mild response to external stimuli to spontaneous hypersensitivity • MIH molars may be difficult to anesthetize
Atypical restorations	• The size and shape of restorations are not conforming to the typical caries picture • In molars the restorations are extended to the buccal or palatal/lingual smooth surface • An opacity can be frequently noticed at the margins

	of the restorations • First permanent molars and incisors with restorations having similar extensions as MIH opacities are recommended to be judged as that
Extraction of molars due to MIH	• Extracted teeth can be defined as having MIH when there are: → Relevant notes in the records → Demarcated opacities or atypical restorations on the other first molars → Typical demarcated opacities in the incisors

The size of the lesion, the level of hypomineralization, and its distribution all affect how severe MIH is. Clinically, there are 3 types. These are (187);

Mild MIH: The stress-free portions of the teeth display isolated, limited opacities. There is no enamel loss due to breakage in opaque areas. No tooth sensitivity or caries exist in the damaged enamel. The incisors are usually mildly affected.

Moderate MIH: The incisal and occlusal thirds of the teeth show limited opacities. PEB is not seen or the presence of caries is limited to 1 or 2 surfaces of the tooth and does not include tubercles. The solid atypical restorations are visible, and there is no tooth hypersensitivity.

Severe MIH: PEB is seen, particularly while teeth are erupting. Tooth sensitivity and caries are quite prevalent because of the damaged enamel. There are atypical restorations with defects.

Categorization plays an important role in making an accurate diagnosis and preparing an appropriate treatment plan. For this purpose, the EAPD has classified these hypomineralized defects as mild and severe (Table 12) (166).

Table 12: Categorization of MIH severity according to EAPD (166)

Severity level	Signs and symptoms
Mild	• Demarcated enamel opacities without enamel breakdown • Induced sensitivity to external stimuli e.g., air/water but not brushing • Mild aesthetic concerns on discolouration of the

	incisors
Severe	• Demarcated enamel opacities with breakdown and caries • Spontaneous and persistent hypersensitivity affecting function e.g., brushing, mastication • Strong aesthetic concerns that may have socio-psychological impact

Management of molar and incisor hypomineralization

These hypomineralized areas are vulnerable to caries formation. Getting rid of these defects is necessary to stop the advancement of demineralized areas and the diffusion of the infection into the pulp tissue. Restorative treatment of the affected teeth helps to rebuild the tooth structure and preserve the function of the tooth. In addition to these advantages, there may be some complications while treating these teeth such as shortening the lifespan of the tooth by increasing their susceptibility to fracture, exposing pulpal tissue throughout caries removal, failure of the restorative treatment and long-term pulpal symptoms as a consequence of restorations (188-190). The long term prognosis is important while deciding the treatment option for the teeth with MIH. Failure of the restorations may result in frequent retreatments which is the reason for high financial burden for the parents and also may have a negative impact on the psychology of the patient (191). According to research, patients with MIH require more dental care than patients without the condition. Moreover, MIH molars that have previously been restored may be in need of retreatment in a short time (192).

The suggested course of therapy comprises six steps (168):

- 1-Risk assessment
- 2-Early diagnosis
- 3-Remineralization and sensitivity reduction
- 4-Dental caries prevention and PEB
- 5- Restorations and extractions
- 6 - Oral health and hygiene

A number of variables should be taken into account while making a proper treatment plan for posterior teeth (Table 13)(166)

Table 13: Factors to be considered for appropriate treatment planning for posterior teeth (166)

At patient level	At oral level	At tooth level
Age of patient	Number of affected teeth	Size of defect
Medical history	DMFT	Location of defect
Ability to cooperate	Developmental stage	Number of surfaces involved
Presence/absence of symptoms	Occlusion	Presence/absence of post-eruptive breakdown
Access to general dental care	Presence/absence of crowding	Presence/absence of atypical or typical carious lesions and extent
Access to specialist care (paediatric dental/ orthodontic)	Presence of third permanent molars	Pulpal involvement
	Hypodontia	History of dental abscess/facial cellulitis
	Need for future orthodontic treatment	

Due to the fact that teeth with MIH are more susceptible to caries, early detection and preventive programs are essential (171,172). Oral hygiene habits may be disrupted in these patients because of the increased sensitivity. A detailed oral hygiene directions and diet modification play an important role in protective programs. These patients are in a high caries risk group, for this reason, topical fluoride agents should be applied regularly (193,194). Plaque accumulation and caries development occur quickly as a result of poor dental hygiene. When moisture control cannot be maintained, glass ionomer cement sealants can be applied to avoid caries formation and lower surface permeability in newly erupting permanent first molars (195).

The hypomineralized surface is extremely prone to erosion and caries during the primary first molar eruption. It is important to evaluate how cariogenic and erosive the child's diet is and to make the necessary dietary adjustment suggestions. Increased dental care should include desensitizing toothpaste. Remineralization therapy should be initiated as soon as the damaged area is accessible in order to produce hypermineralization on the tooth surface and to reduce tooth sensitivity (196,197).

Resin-based fissure sealants may be used as a defense against dental caries and post-eruptive breakdown for fully erupted molars (198,199), with the use of an adhesive while placing since it has been made abundantly clear to improve the retention (198).

Oral care products with "casein phosphopeptide-amorphous calcium phosphate" (CPP-ACP) can be utilized for this purpose. In addition, remineralization of enamel, reduction of sensitivity and change of resistance to demineralization can be achieved with topical fluorides, varnishes or gels (200).

However, *Bullio Fragelli et al.* (2015) assessed the possibility of caries formation and post eruptive breakdown in teeth with MIH. They showed that new breakdowns continued to develop even with frequent clinical monitoring and preventative therapy, such as the use of fluoride varnish, particularly in parts with yellow and brown opacities (201).

Restoration of affected first permanent molars is challenged by difficulties in providing anesthetic, elevated patient anxiety, determining the amount of the affected enamel that should be removed, and challenges in choosing the appropriate restorative material (164). In the affected tooth, due to the chronic inflammation of the pulp tissue, providing anesthesia becomes complicated (197,202).

Jälevik et al. (2002) analyzed the need for restorative care, dental anxiety, and behavioral management issues in patients with severely hypomineralized first molars. Their results showed that around ten times more first molar dental treatments had been performed on patients in the research group than on those in the control group (202).

When restoring teeth affected by MIH, there are two methods for determining the cavity margins: in the first, all damaged tissue is removed; in the second, only highly porous enamel is removed (197). When all damaged enamel is removed, early restorative failures are avoided, but a significant quantity of tooth structure is removed. A conservative strategy is to selectively remove highly porous enamel, however restorations are susceptible to marginal fracture. In order to treat these individuals, a variety of restorative material alternatives are available. The choice of material will depend on the defect's severity, the child's cooperation, and their age (195,197). These restorative materials include; glass ionomer cements (GIC), resin modified glass ionomer cements (RMGIC), polyacid modified composite resins, composite resins, prefabricated stainless steel crowns, indirect adhesive or cast restorations (195).

Glass ionomer cements

MIH affected teeth may be restored with glass ionomer cement (GIC) temporarily, until the final restoration, or before an age-scheduled extraction, to protect the tooth when a child refuses to cooperate for invasive treatment needing local anesthetic application, or cannot obtain dental

care. GICs have the ability to release fluoride and can be used in cases when the moisture control cannot be obtained. These properties of the material makes it suitable for treating teeth with MIH. On the contrary, due to the fact that it has poor mechanical properties, especially in stress bearing areas, the failure rates of the treatment is high (203,204).

Polyacid modified composite resins (Compomers)

The materials known as polyacid modified resin composites are easy to manipulate, fluoride-releasing, and have a tensile strength that is lower than that of resin composites but higher than that of GIC and RMGIC. Because only stress-free portions of permanent teeth should be restored using polyacid modified resin composites, their application in hypomineralized permanent molars is also restricted (195,197).

Composite resins

While restoring the teeth with MIH using composite resins, isolating the teeth with a rubber dam increases the chance of success (166,205-207). Advantages of composite resins are that; the application procedure is easy, treatment can be finished in a single session, and the future defects on the restorations can be quickly fixed. Due to the fact that hypomineralized enamel has a lower bond strength (208), it is advised to remove all the affected enamel to increase adhesion while treating these teeth with composite resins (209).

In both total and self-etch systems, the bond strength of resin composites to normal enamel is greater than the bond strength to hypomineralized enamel in affected first permanent molars. In affected teeth, the enamel's mineral concentration decreases while its protein level rises, which has a negative influence on bonding and etching (210).

Before the adhesive systems, clearing the cavity with 5% sodium hypochlorite was a method that has been tried in the literature to decrease the protein content of the affected enamel and increase the bonding between composite resins and the cavity walls. *Sonmez et al.* (2017) performed a study in order to assess the clinical impact of deproteinizing on the quality of restorations using composite resins. No significant difference was found between the groups that were administered sodium hypochlorite and the groups that were not. However it was seen that deproteinizing the affected enamel improved bonding rates (211).

Stainless steel crowns

When permanent first molars have moderate to severe PEB, prefabricated stainless steel crowns are a possible treatment option. These crowns are not technically sensitive or costly, and they don't take a lot of time to prepare and apply. They also prevent additional tooth decay, avoid tooth sensitivity, provide proper interproximal contact and occlusal relationship (195,197).

With the use of these crowns, structural integrity is preserved and the restoration of the teeth can be done in one appointment (206).

To have a proper fit of the crown, tooth preparations can be done, as well as orthodontic separators can be placed to create space for the crown proximally (212).

Indirect restorations

In circumstances when many surfaces of the teeth are affected, indirect restorations may be preferred instead of direct restorations owing to their higher success rates (204,213,214). Composite resins can be used while preparing indirect restorations with the benefits of minimal preparation requirements and easy fixing in failure situations (213).

Unlike SSCs, indirect restorations have less negative effect on periodontal tissue. As with direct composite restorations, all affected enamel must be removed to ensure good bonding. The disadvantages of this technique are that the application takes a long time, the need for temporary restoration between sessions and the precision of the preparation technique (213,214).

Extractions

Restoration may become impossible and extraction may be considered when permanent first molars are severely damaged. While considering the extraction of the molar tooth, dental age, the vitality and restorability of the tooth, crowding in the arch, occlusal relationship, and the condition of other erupted or unerupted teeth should be evaluated (195,215). Malocclusions, missing or supernumerary teeth, crowding, dental developmental stage and third molars are the other criteria that should be assessed while planning extraction. When these criteria are examined, even if ideal conditions are provided, a complete closure between the teeth may not be achieved (216).

If the extraction of permanent first molars is planned, it is preferable to have these teeth extracted between the ages of 8.5-9. These ages, which are the most suitable times for the proper alignment of the second molars and the closure of the spaces, coincide with the bifurcation calcification time of the mandibular permanent second molars (215).

2.7. Management of Caries Lesions of Primary Molars

Planning of restorative treatments is a process that requires the evaluation of the child's degree of caries risk, the durability and biocompatibility of the materials to be used, the developmental stage of the dentition, the patient's cooperation and many other factors (217). The dentist should choose materials that are unique to each case while taking into account aspects like cost-effectiveness, durability, allergy potential, and aesthetics (218).

Dental caries are managed through (113);

- 1) Primary prevention: Aims to stop a disease before it happens. Consequently, This strategy targets healthy people. (brushing teeth via age appropriate- fluoridated toothpaste, topical fluoride application, dietary restrictions, oral health education)
- 2) Secondary prevention: Focuses on detecting the disease at an early stage. (preventing the non cavitated caries lesions' advancement, topical fluoride application)
- 3) Tertiary prevention: Targets the patients suffering from the consequences of a disease and focuses on minimizing the impact of the disease. (Both non-invasive and invasive treatment of the cavitated lesion.

Nowadays, dental treatments involve identifying the caries risk of the patient, preserving oral health by early diagnosis and using preventative strategies, and avoiding the development of initial caries lesions (75). Early preventative measures can reduce the risk of dental caries and stop its progression. These measures attempt to change the oral environment to one that is non acidogenic (219). Children should brush their teeth twice a day with a toothpaste containing an appropriate amount of fluoride and with the support of their families to prevent caries. This support should continue until the children's ability to brush their own teeth develops. At the same time, nutritional advice should be given to children and families, and information should be given on reducing the consumption of refined sugars. Fissure sealants and topical fluoride applications should be applied within the scope of protective applications (220).

The enamel and dentin thickness of primary teeth is thin, the distance between the tubercles and occlusal distance is short, the proximal contacts are straight, the cervical enamel rods are oriented towards the occlusal, there is a sudden narrowing of the crown in the cervical region when compared to permanent teeth. These factors significantly affect the success of the restorations applied to primary teeth (221,222).

Amalgam and stainless steel crowns, as well as fluoride-releasing restorative materials including glass ionomers and compomers, and composite resins are frequently used in primary and mixed dentition (223,224). When deciding on a suitable treatment approach for a pediatric patient with deep carious lesions in the primary teeth, a dentist must take into account a number of different criteria including; overall health of the patient, dental condition, compliance of the patient, markers of pulpitis; cavity dimensions, expectations of parents, price of the treatment and clinical expertise of the dentist (225). The choice of restorative materials is also influenced by the short lifespan of primary teeth in the mouth and the limited treatment times in young patients (226).

Deep carious lesions are common in pediatric patients, and they need to be treated immediately (227). The increased risk of additional caries advancement can be decreased by restoring the

tooth surface using preventative restorative materials. In order to stop the advancement of caries and prevent recurrent caries in patients aged 3-6 years, protective restorations and topical fluoride application are crucial (228,229).

The manipulation of dental restorative materials is crucial since it affects the material's final structure. The materials in powder/liquid form are not prepared at the recommended rate and ideal temperature and the mixing speed may cause the reaction to take place faster or slower. These factors have a direct impact on the material's mechanical and chemical structure. For this reason, using resin-based products in ready-mix or capsule form reduces human application mistakes compared to using materials that are mixed manually from powder and liquid (230). With the development of adhesive techniques, the need to remove extra dental tissue for the retention of the applied material has decreased, and more conservative cavity preparations have begun to be made (231). Using restorative materials that can bind to dental tissues while removing the bare minimum of dental tissue is crucial in modern dentistry (232).

2.8. Noninvasive management

For the treatment of non-cavitation caries lesions diagnosed after clinical examination, non-invasive treatment methods such as topical fluoride applications, silver diamine fluoride (SDF) application, resin infiltration method and fissure sealant applications can be preferred after the risk group of the patient and the clinical and radiographic features of the carious lesion are evaluated. Before non cavitated caries lesions turn into cavitated lesions, noninvasive treatment methods could potentially provide a conservative option against invasive restorative therapy (233,234).

2.8.1. Topical fluoride application

Topical fluoride applications are the most successful and popular means of preventing dental caries (235). The continuous presence of fluoride in the oral cavity decreases mineral loss during demineralization and speeds up remineralization, increasing the enamel's strength (22,236).

Topical fluoride treatments aim to enhance remineralization. Remineralization is intended to prevent and reverse the development of the initial caries lesions (22,237). Fluoride can be applied to teeth by dentists in forms such as varnish, gel and paste (238).

Regular topical fluoride applications are regarded as a non-invasive caries treatment strategy. It was discovered in research to be successful in preventing the advancement of initial caries lesions (18). Systematic reviews have shown that regular application of 5% sodium fluoride

varnish can prevent the development of new caries in primary teeth and help remineralize early enamel lesions (239,240). Regular applications every three to six months are necessary to maintain effectiveness (241). Studies have shown that at least 63.6% to 81.2% of enamel caries lesions are inactivated after fluoride varnish application. For cavitated lesions, fluoride varnish is effective in 30% of cases. Sodium fluoride varnish has a moderate efficacy in remineralizing and/or stopping early enamel caries lesions and a lower efficacy for cavity caries lesions (18,242).

2.8.2. Silver diamine fluoride

SDF was developed in Japan in the late 1960s by combining the antibacterial properties of silver ions with the preventive effects of fluoride ions (243). It was approved by the U.S. Food and Drug Administration (FDA) for the treatment of tooth sensitivity in 2014 (244). SDF has been accepted as a caries preventive agent in the list of essential drugs for children published by the World Health Organization (WHO) in 2021 (245).

Silver (Ag) ions in SDF inhibit the growth of *Streptococcus mutans* and reduce the metabolic activity of *S. mutans* in dental plaque. Fluoride ions in SDF prevent the progression of caries (246). It has been suggested that the caries process can be stopped and new lesion development can be prevented with the synergistic effects of silver and fluoride ions (247). The American Academy of Pediatric Dentistry (AAPD) recommends the use of SDF for caries management in children and adolescents, including children with special health care needs. In cases when other choices are unavailable, topically administered silver diamine fluoride is a practical substitute to stop ECC and root caries lesions (154).

According to the Silver Diamine Fluoride application guidelines of The American Academy of Pediatric Dentistry (AAPD), SDF indications and contraindications are listed below (154):

Indications

- Patients with multiple caries lesions that will require multiple appointments
- Patients with caries lesions extending to dentin in anterior and posterior primary teeth
- Active carious lesions without pulpal involvement
- Patients with limited or no access to dental care services
- Patients with behavioral problems or systemic conditions who need dental treatment under general anesthesia

Contraindications

- Spontaneous or severe pain due to caries
- Caries lesion near the dental pulp confirmed by clinical and radiological findings

- The patient or parents do not accept the coloration due to SDF
- Individuals with silver allergies

In the review published by *Zhao et al.* in 2018, the mechanism of action of SDF was examined under 4 main headings (248):

1. The effect of stopping caries lesions and preventing caries
2. Antibacterial effect
3. Inhibit enamel and dentin demineralization and increase remineralization
4. Prevention of collagen matrix degradation by inhibition of collagenase enzyme

It has been reported that the caries-preventive effect of silver diamine fluoride is primarily due to its antibacterial properties on cariogenic bacteria, but it is also associated with providing remineralization on the mineral structures of the tooth and preventing the degradation of the organic matrix (248). While fluoride supports remineralization; silver plays a role in antimicrobial activity (249).

It was discovered that applying 38% SDF twice a year was beneficial in preventing the progression of initial caries. Owing to this application, invasive procedures are avoided or postponed, especially in children with cooperation challenges (225).

Enamel density rises and lesion surface hardness increases as the treated lesion depth decreases. It has been claimed that demineralized dentin treated with SDF has more silver and fluoride deposited in it than healthy dentin, making it more resistant to caries-causing bacteria (249). In a recent study, *Sulyanto et al.* (2021) assessed the mineral density and elemental analysis of primary teeth treated with SDF. They found that, in comparison to the control group, the mineral density of SDF-treated teeth increased in the area where silver ions were concentrated. This finding supported the biomineralization effect of silver ions (250).

When SDF is applied to the surface of the enamel, it interacts with the hydroxyapatite to create silver phosphate, calcium fluoride, which serves as a fluoride reservoir, and phosphate ions that aid in remineralization (251). According to *Mei et al.* (2017), SDF generated fluorohydroxyapatite when it reacted with the calcium and phosphate in saliva (252).

Dentin remineralization can take place either by intrafibrillar attachment of minerals or extrafibrillar deposition of minerals between collagen fibrils. Dentin demineralization and collagen breakdown are both inhibited by silver diamine fluoride (253). *Rosenblatt et al.* reported in 2009 that SDF had a 96% success rate in stopping and preventing caries, while the use of 5% NaF varnish had a 55.7% success rate (247).

Increasing the frequency of application of silver diamine fluoride increases the chances of preventing the progression of caries lesions (248). *Gao et al.* (2016) examined the effect of SDF

on caries arrest and concluded that twice-yearly SDF application was more effective in caries-stopping than once-yearly SDF application. It has been stated that applying SDF 3 times a year is much more effective in stopping caries (153).

In a meta-analysis published in 2020 by *Jabin et al.*, it was reported that 38% concentration of SDF was more effective in stopping caries in primary teeth than lower concentration SDF applications and fluoride varnish applications (254).

SDF assists the tooth to develop tertiary dentin due to its remineralizing and antibacterial properties. When SDF is used on caries lesions that are close to the pulp, pulp irritation can be observed as a side effect; however, additional clinical research is required on this topic (255). According to *Bimstein et al.* (2018), SDF treatment inhibited pulp exposure and led to the production of irregular tertiary dentin. Also, it was noted that no bacteria were detected up to a depth of 1 mm in the dentinal tubules, where Ag deposits were observed. It has been noted that the use of 38% SDF in teeth with deep carious lesions that are adjacent to the pulp avoids pain, pulp exposure, and pulp degeneration (256).

2.8.3. Resin infiltration

Resin infiltration is a procedure applied to the caries that are not cavitated, to stop the advancement of the lesion (257,258). A low viscosity resin is expected to diffuse into the caries lesion and after polymerization, acts as a defense against acid attacks (259,260). Lesions confined to the outer third of the dentin can be treated with the application of resin that penetrates to the pores (261).

Faghihian et al. (2019) concluded in a systematic review and meta analysis that the resin infiltration procedure is a successful treatment option to stop the advancement of initial caries for primary and permanent teeth (262).

Sarti et al. (2020) compared the efficacy of resin infiltration applied to the proximal caries lesions with the no infiltration group. They found that infiltration procedure stops the caries advancement when examined radiographically after two year follow up period (263).

2.8.4. Fissure sealants

Pits and fissures of tooth surfaces are especially sensitive to caries formation (264). This is seen as a result of the fact that pits and fissures are prone to plaque accumulation anatomically, their cleaning ability is low, and they do not benefit from fluoride applications as much as other surfaces of the tooth (265).

Fissure sealants are materials applied to pits and fissures of teeth that are prone to caries. It prevents the formation of caries by covering the chewing surfaces of the teeth and prevents the progression of non cavitated caries lesions in the initial stage (266). Pit and fissure sealants act as a physical barrier between the enamel and the oral environment, reducing the accumulation of food debris and plaque (267,268). With the growing popularity of minimal invasive dentistry, fissure sealants have also been introduced to treat active initial fissure caries and even to stop non-cavitated fissure caries. Findings from the present meta-evaluation support the use of fissure sealants to stop non-cavitated occlusal caries. Placement of a fissure sealant over a non-cavitated caries lesion prevented cariogenic bacteria in the biofilm from accessing nutrients, thereby changing the balance in favor of remineralization (267). There is no need for local anesthesia during the application. Resins, glass ionomer cements and compomers are used as fissure sealant materials (269).

Resins

Resin-based fissure sealants are applied to the tooth after etching. This material provides a very good sealing on the surface of the fissures, cutting off their contact with the oral environment and preventing the formation of caries (269). They can be found in opaque, tinted or transparent form. Although there is no clinical difference between these species in terms of retention, clinical detection of opaque and tinted ones is easier (270).

Glass ionomer cements

Without the need for etching, glass ionomer cements are chemically attached to the tooth surface (271). Upon application, they are not very sensitive to moisture. They release fluoride into the environment after application (272). The studies have revealed that resin-based fissure sealants have a higher retention rate than glass ionomer cements (273,274). Yet even if the GICs move away from the tooth surface, the fluoride release and residues in the fissures ensure that the teeth are still preserved (275,276). Glass ionomer cements are recommended for teeth that are newly erupting and moisture control cannot be achieved, and for high-risk patients (277).

Compomers

Polyacid modified resin-based composite resins, also called compomers, has also been used as a fissure sealant. It contains 70-80% composite resin, 20-30% glass ionomer cement and 13% fluoride. The physical properties of compomers are similar to composites, but their wear is more and their fracture resistance is lower than composite resins (278). In a clinical study evaluating the retention and caries prevention properties of compomer-based fissure sealants, it was

reported that their retention was low but they were found to be successful in caries prevention (279).

The progression of the initial caries lesions without cavitation seen on the occlusal surface can be prevented by fissure sealant applications. The use of the fissure sealant prevents the bacteria in the caries lesion from accessing to the substrate needed for acid production, thus inhibiting the lesion's development. To implement a successful protocol, the tooth should be isolated very well during the procedure and should be examined often (258). This application is recommended in cases where the caries is limited to the enamel. It was found appropriate to apply preventive resin restorations in lesions that progressed to the dentin (270).

In cases where discoloration is detected in the pits and fissures, bitewing radiography is taken in addition to the clinical evaluation and the limits of the discoloration are examined. If, as a result of the evaluation, it is observed that the discoloration is limited in the enamel, the tooth is followed regularly by applying fissure sealant. Bitewing radiographs can be obtained in suspicious cases at follow-up appointments. Fissure sealants can be repaired in cases where defects are detected on the surface (269).

2.9. Invasive management

Invasive caries treatment methods are performed by removing the caries with burs and hand tools and applying a suitable restorative material (280). Requires local anesthesia applications due to pain during caries removal. Amalgams, glass ionomer cements, compomers, composite resins can be used for this purpose. In addition, pediatric crowns are among the invasive treatment methods (281).

2.9.1. Amalgam restorations

For more than 150 years, amalgams have been preferred to treat tooth decay in the posterior teeth (282). Together with around 50% mercury, dental amalgam is a material that includes a combination of metals like silver, tin, and copper (283). Amalgam has a long shelf life, is inexpensive, and restoration can be easily repeated. Although the use of adhesive materials for the restoration of posterior teeth continues to increase, amalgam is still an alternative to restorative materials for many dentists (284). However, due to the harmful effects of mercury in amalgam's composition on human health, the harm of its waste to the environment, and the rise in desire for aesthetically pleasing restorations, the use of amalgam in the treatment of decayed teeth has recently declined (282).

Advantages

Although residual caries in the cavity or the patient's risk of developing caries are frequently linked to the formation of secondary caries, it is also suggested that the applied restorative material may have a predisposing or preventative influence on the development of secondary caries (285). The success rate of amalgam restorations is increased by the fact that dental amalgam is less likely than resin-based materials to develop secondary caries.(286) Dental amalgam could be chosen for primary tooth restorations over resin-based materials since it needs less technical precision and moisture control (287).

Disadvantages

Dental amalgam has a number of disadvantages, including the fact that it doesn't chemically bind to tooth tissues, requires invasive cavity preparation, has a high thermal conductivity and low fracture resistance (287).

Since amalgam can only adhere to tooth structures mechanically and the necessity of removing caries-free structures in teeth to be restored with amalgam makes amalgam inadequate in conservative treatment. The mechanical attachment of amalgam to the tooth structure causes microleakage between the amalgam and the tooth surface. Microleakage is a problem for amalgam restorations, although it has been shown that over time this gap becomes filled with amalgam corrosion products and microleakage decreases. The loss of marginal adaptation brought on by the occurrence of marginal fractures is another disadvantage of amalgam (288). It has been noted that there is insufficient long-term evidence about amalgam's effects on pregnant women, the growing fetus, and children under the age of six (289).

In a randomized clinical research with an 8-year follow-up period, Qvist *et al.* (2004) compared the durability and cariostatic effects of conventional glass ionomer and amalgam restorations in primary teeth. They revealed that, 42% of glass ionomer restorations and 20% of amalgam restorations had been replaced or fixed, 50% of teeth restored with glass ionomer and 63% of teeth treated with amalgam were exfoliated while the restoration was still in place. The main causes of failure of the treatments were loss of retention, endodontic issues, and restoration fractures. The average survival duration for dental amalgams could not be calculated but was greater than 7.8 years, while the 50% survival time for glass ionomer restorations was 42 months, regardless of cavity type. They concluded that, despite the fact that conventional glass ionomer restorations slow the progression of caries and decrease the requirement for treatment of the contact teeth, GICs are not suitable to use instead of amalgams in primary teeth, because of their high failure rates (290).

To determine the durability and causes of failure of amalgam, glass-ionomer, stainless steel crowns, composite, and compomer restorations in stress-bearing cavities of primary molars,

Hickel et al. (2005) analyzed the dental literature. Yearly rate of failure for SSCs were found to be 0-14%, for glass-ionomer restorations 0-25.8%, for dental amalgams 0-35.3%, for atraumatic restorative treatments 2-29.1%, for composite restorations 0-15%, and for compomer restorations 0-11%. Recurrent caries, fracture, and wear were found to be the main causes of failure (226).

Belligner et al. (2006) investigated the outcomes of dental amalgam on neuropsychological and renal function and compared the results with composite restorations. They found no statistically significant difference between two groups over the five year period (291).

DeRouen et al. (2006) examined neurobehavioral impacts of dental amalgam during a 7 years trial period. They concluded that children treated with dental amalgam showed no statistically significant difference in neurobehavioral assessment compared with children treated with composite resins (292).

By contrast, the Food and Drug Administration (FDA) of the United States published guidelines that involve safety warnings about possible side effects for people with mercury sensitivity, potential risks caused by mercury vapors and declaration of mercury levels in the content. Additionally, FDA stated that there has been insufficient data on long term effects of dental amalgam on the health of pregnant women, growing fetuses and children under six years of age (283).

Soncini et al. (2007) examined the replacement rates of amalgam, compomer and composite restorations in posterior teeth during five years. They concluded that even though average lifespan differences were not statistically significant, composite restorations needed to be fixed more than amalgam restorations and compomer restorations needed to be replaced more often due to secondary caries (293).

2.9.2. Glass Ionomer Cement Restorations

Ever since the early 70s, glass ionomer cements have been used in dentistry for various purposes including luting agents, cavity liners and restorative materials (294). Due to the fact that they have some disadvantages like prolonged setting time, poor wear resistance and limited fracture strength, there have been some improvements in the composition of the material (295), which lead to production of resin modified glass ionomer cements (RMGIC). These materials demonstrated better handling qualities, higher strength, reduced setup time and enhanced wear resistance (296).

Glass ionomer cements differ from composite resins in a number of important ways. First of all GICs bind to enamel and dentin chemically. Secondly, they have the ability to release fluoride

and can be recharged by the fluoride from toothpastes, topical fluoride applications and mouth rinses, and enhance the tooth's durability against acid attacks (297). Fluoride-containing dental materials can serve as a fluoride reservoir, raising the amounts of fluoride in saliva, plaque, and hard tooth tissues. Moreover, it may reduce or assist prevent secondary caries (298). The matrix of the material, the setting process, the fluoride concentration, and different environmental factors all affect how long and how quickly fluoride is released from restorative materials (299). The acid-base reaction causes a quick release of fluoride during the hardening of GIC, which is followed by a rapid decline in the rate of release (300). They have reduced moisture sensitivity when isolation cannot be obtained properly. Their thermal expansion is closer to enamel and dentin (295). The most important disadvantage of CGICs is its fragile structure and poor long-term performance under the chewing force (224).

Conventional glass ionomer cements are biocompatible materials that chemically bond to enamel and dentin. Fluoroaluminosilicate glass powder and diluted polyacrylic acid undergo an acid-base reaction, which causes the polymerization of the material (301).

A research conducted on primary molars found that because CGICs are so sensitive to moisture during the curing process, their bond strengths are lower than those of resin modified glass ionomer cements. This scenario results in low compression-tensile strength and fracture resistance, particularly in regions where chewing force is significantly high (224). Conventional glass ionomers are not suggested for Class II cavities in primary molars according to the outcomes of a systematic review and meta-analysis published by *Chadwick et al.* (2007)(302). In order to overcome the CGICs pre-existing disadvantages, *high viscosity glass ionomer cements* were developed in the early 1990s by mixing polyacrylic acid with high viscosity powder. By doing this, the material's physical characteristics, such as wear resistance, have been improved (303). Due to its qualities including biocompatibility, chemical adhesion to dental tissues, fluoride release, and fluoride recharge, high viscosity glass ionomer cements may be used, especially for the treatment of primary teeth with Class I and II cavities (304).

Resin modified glass ionomer cements (RMGIC), have been proven to be a successful alternative that can be used to restore primary teeth (305). RMGICs are advantageous to patients in high caries risk groups due to their fluoride releasing property. Resin modified glass ionomer cements have been developed by mixing resin monomers into CGIC, enhancing the material's mechanical qualities such as sensitivity to moisture and abrasion and fracture resistance (306). Polymerization of this material occurs via an acid base reaction, followed by photopolymerization (305). It has been stated that these materials are easier to use than conventional ionomer cements, have enhanced mechanical characteristics, allow for quick

finishing and polishing in the same session, and have significantly better aesthetic qualities (307).

Like CGICs, RMGIC has the ability to chemically bind to dental tissues and release fluoride. In addition, it provides ease of use in primary teeth with its features such as easy preparation and application, long and controlled working time due to its resin content (308). The addition of a resin matrix to the material allows these resin-based cements to adhere to composite restorations and to be used as a liner or base material in primary and permanent tooth cavities (309).

According to research, RMCIS is clinically just as effective as amalgam in class II restorations of primary teeth, and teeth restored with RMCIS show fewer recurrent caries at the restoration margins (310).

Toh et al. (2007) examined the performance of GICs, RMGICs, composite resins and polyacid modified composite resins. As a result of this meta-analysis, RMGICs were found to be more successful than conventional GICs, when restoring proximal lesions in primary teeth (305).

Yengopal et al. (2011) conducted a study to compare the caries prevention impact of RMGIC and composite resins. They concluded that caries prevention activity of RMGICs is better than composite resins (311).

Glass ionomer cements are restorative materials that have the ability to adhere to dental hard tissues, are biocompatible, release fluoride, and display the required amount of thermal expansion and contraction. Together with these advantageous characteristics, being hydrated during the curing reaction, inadequate compressive and tensile strength, and poor aesthetic qualities have resulted in lower success rates when compared to other materials (305).

2.9.3. Interim therapeutic restoration (ITR)

It is a preferred treatment approach in cases where dental treatments cannot be applied immediately in patients who are at a young age and have cooperation problems, and in individuals who require special care (312,313). It can be applied to temporarily treat caries and to control cariogenic oral microbiota before treatment under general anesthesia in patients in whom many teeth are affected by caries (314). It can be used in the treatment of primary and permanent teeth. Permanent treatment of teeth temporarily treated with this method should be done within 6 months. Otherwise, the success rate of the treatments will decrease (315). Glass ionomer cements used in this treatment approach have an effect on enamel and dentin to increase resistance to acid produced by cariogenic bacteria (316).

2.9.4. Atraumatic restorative treatment (ART)

Atraumatic restorative treatment (ART) is a minimally invasive approach to the treatment of caries lesions that involves removal of demineralized tissue with only hand instruments to keep pain to a minimum (317). ART is a treatment procedure that uses a similar method with ITR but has a slightly different goal. This method serves as a primary treatment option to heal caries lesions in communities with limited access to dental services (318).

Since the application of ART method in teeth where more than one surface is affected by caries causes high failure rates, it is recommended to be preferred in teeth where only one surface is affected (225).

Recently, the silver modified atraumatic restorative treatment (SMART) technique has been developed, which involves treating the carious lesion with SDF and then restoring it with glass ionomer cement. SMART is a preferable alternative for ART restoration and enhances treatment outcomes (319).

Frencken et al. (2007) compared ARTs with conventional amalgam restorations in order to assess their suitability to supplement preventative and educational school oral care programs. As the evidence suggested, ART strategy offered greater survival rates for single-surface restorations than the amalgam restorations and is thus acceptable for implementation in school oral health programs (320).

Amorim et al. (2018) published a systematic review and meta-analysis about survival rates of ARTs and concluded that in both primary and permanent posterior teeth, single surface restorations had excellent survival rates, but multiple surface restorations had poorer survival percentages (321).

Ebrahimi et al. (2020) evaluated the clinical and radiographic findings of three treatment techniques retrospectively. These techniques are the Hall Technique (HT), Stainless Steel Crowns (SSC) and modified ARTs (mART). They also analyzed patients' reactions during these treatments. They observed higher failure rates for mARTs. The patients reaction to the treatment was significantly better for the patients treated with SSC (322).

2.9.5. Compomer restorations

In the mid-90s, compomers (polyacid modified resin based composites) were developed and started to be used in pediatric dentistry. By enhancing the physical and mechanical characteristics of CIS, compomers, fluoride-releasing hybrid materials with characteristics similar to those of composite resins, are created. This material has the ability to release fluoride,

it is easy to handle during application procedure, and has good esthetic properties. These advantages lend support to claim that this material can be an effective treatment alternative in pediatric dentistry. Indications of compomers include the restoration of Class II and V cavities, fissure sealing material, and orthodontic bands' cementation (323).

CGICs are chemically attached to dental tissues by chelation of calcium carboxyl groups and polyacids of apatites in enamel and dentin, unlike compomer restorations, which are micro-mechanically bonded to dental tissues through the production of resin tags. In this respect, compomers are chemically similar to composites rather than CGICs (226).

While compomers are classified as caries preventive materials because of their capacity to release fluoride, their release rate of fluoride is lower than that of CGICs and RMGICs (324).

Attin et al. (2001) assessed the clinical performance of compomers and hybrid resin based composites in class II cavities with a three year follow up period. This literature showed that there were no statistically significant differences between these two materials in terms of esthetic values, discoloration rates, marginal integrity and recurrent caries (325).

Duggal et al. (2002) compared the clinical performance of compomers with amalgam restorations in Class II cavities. Compomers had significantly superior marginal integrity. However, both compomers and dental amalgams share similar properties in terms of occurrence rates of secondary caries, wear of the material against occlusal forces and surface roughness (326).

Yildiz et al. (2015) compared the fracture resistance of different restorative materials used in Class II cavity designs for primary molars. The researcher utilized 80 extracted, healthy human primary molars. The restorative materials that were put to the test were composite, resin-modified glass ionomer cement (RMGIC), compomer, and glass ionomer cement (GIC). For fracture strength, the restorations underwent testing. Compared to the GIC and RMGIC groups, the composite and composite group's fracture strength was noticeably higher (327).

2.9.6. Composite restorations

Resin-based composites have been used as filling materials for about 70 years which are produced as an esthetic alternative for dental amalgams. Composite resins are preferred for protective resin restorations, anterior tooth restorations, and Class I and II restorations in pediatric dentistry (310,328) because they are aesthetically pleasing materials with controlled curing qualities and adhesive binding to tooth structures (329).

The disadvantages of composite restorations include the need for a sensitive application method, the fact that they take longer to apply to the cavity than amalgam and other restorative

materials, and a reduction in biocompatibility because of the presence of bisphenol A. The displacement of the composite resin from cavity walls due to polymerization shrinkage is another issue that results in deteriorated adhesion and the development of marginal gaps (330). Marginal gaps may lead to pulpal pathologies that can be defined as failure, postoperative sensitivity, discoloration and secondary caries (331).

Experience level of the dentists, size of the caries lesion and position of the tooth are all aspects that contribute to the lifespan of resin composites (286). Resin based restorative materials need a prolonged placement time due to bonding procedures and the technique used is more sensitive compared to amalgam restorations. When the patient is not cooperative or isolation of the tooth is not possible due to various reasons, resin based composites may not turn out to be the best treatment option. Extensive caries lesions when more than one surface of the tooth was affected, children who are at high risk group due to poor oral care and patients who have multiple teeth affected by caries lesions are not the best options to use resin based composites during treatment procedure (332).

In a randomized clinical trial, *Bernardo et al.* (2007) evaluated the survival rates and causes of failure of posterior amalgam and composite restorations. The 472 participants, whose ages varied from 8 to 12 years, were divided equally between receiving amalgam restorations for their posterior teeth and receiving resin-based composite restorations. Yearly follow-up oral examinations and bitewing radiographs were performed on participants. Failures included restorations that needed to be replaced. Several causes of restorative failure were noted by the researchers. Amalgam restoration's survival rate was 94.4 percent, compared to 85.5 percent for composite restorations. For amalgams, annual failure rates varied from 0.16 to 2.83 percent, while for composite restorations, they ranged from 0.94 to 9.43 percent. The primary cause of failure in both restorative materials was secondary caries. The composite group had a 3.5 times higher risk of recurrent caries (286).

Casagrande et al. (2013) compared the clinical success of composite resin and RMCIS. The sample of the study included 132 primary molars that had occlusal and occlusal-proximal surface cavitated carious lesions that were categorized as active lesions. The recall interval was set at 6 months and the follow-up lasted after 18 months. They claimed that both materials were found to be statistically similar regardless of the survival rates of the materials, the number of surfaces restored, and the caries removal technique. Researchers have suggested that the type of restorative material containing resin used in primary teeth does not affect the longevity of the restoration (333).

2.9.7. Crown restorations

Crown restorations were first introduced in 1947 by the Rocky Mountain Company (334). Crowns reduce the long-term failure factors that other restorative materials share. Crowns for primary teeth are produced in many different sizes and are used for the restoration of pulp-treated or developmentally defective teeth and patients who are in a high risk group (335).

In children who are susceptible to developing caries or in children who cannot be followed up for a long time and cannot attend control sessions, this form of restoration provides a preventive effect against recurrent caries (336). In addition to those listed, other advantages of pediatric crowns are outlined in the table with their disadvantages (Table 14)(337).

Crown restoration is more desirable due to the high failure rate in restorations of teeth with severe material loss. Indication of crown restorations include (338);

- Children with high caries risk and lack of cooperation against rotary instruments,
- Teeth that have undergone endodontic treatment,
- The treatment of advanced approximal caries,
- Patients treated under general anesthesia,
- The treatment of broken teeth due to trauma or various reasons,
- The presence of multi surface caries,
- Patients with bruxism,
- The treatment of defects in the cervical regions.

Ideal features for crown restorations include (338);

- Good esthetic properties,
- Chewing function must be maintained,
- Life span ought to be comparable to that of a primary tooth,
- Prevented teeth from breaking,
- Does not cause the opposing tooth to wear down in any way
- It should be simple to use,
- Regain lost functionality.

Today, the most commonly used crown restorations in the treatment of primary teeth are (337);

- Stainless steel crowns
- Polycarbonate crowns
- Strip crowns
- Pediatric jaket crowns
- Crowns created with the CAD/CAM system

- Zirconium crowns

Table 14: Advantages and disadvantages of pediatric crowns (337)

	Advantages	Disadvantages
Stainless Steel Crowns (SSCs)	• Proper occlusal closure is provided • Periodontal problems are prevented due to the contour and marginal fit • Pulp is preserved in vital teeth • Preserves mesio-distal tooth size and arch length • has a long lifespan • Good patient compliance during and after restoration	• May cause gingival compliance problem and periodontal problem • Tooth loss can also be seen in cases where the tooth is prepared much. • Not good esthetics properties
Open face SSCs	• It offers the possibility of use in the front area • Can be applied in a single session	• Requires preparation intraorally • Long duration of treatment • Fractures appear due to occlusal forces • Not aesthetically pleasing
Preveneered SSCs	• No preparation is required intraorally • Esthetically pleasing • Less affected by the salivary environment • The time spent by the physician on the patient	• Contouring is performed only on the palatal/lingual surface, as fractures may occur on the facial surfaces during contouring

	has decreased	• Color options are limited • It is difficult to apply in children with limited space due to crowding in the arch • More dental tissue is prepared due to passive fit to the tooth structure
Polycarbonate crowns	• Esthetically pleasing • Flexible • Good adaptation is ensured	• Easily breakable • Color change can be observed • Limited retention
Strip crowns	• Good esthetics • Glossy and smooth surface can be obtained • Economic • Result very similar to natural tooth appearance can be achieved • Can be applied easily and quickly	• Requires precise technique • Contamination with blood and saliva should be prevented. • In order for the bonding material and the composite to bond properly, the remaining tooth tissue after preparation must be in sufficient quantity. • It is difficult to apply to very young children due to cooperation problems

Pediatric jacket crowns	• Some of the preparations can be done extraorally • Intraoral working time is reduced • Relatively easy to use in children with a lack of cooperation	• Wear may occur with occlusal forces • May change color over time • The separation of the crown from the cement can be seen
Crowns created with the CAD/CAM system	• Good esthetic • Intraoral working time is short • Treatment is completed in one session • It is easy to apply in children as there is no need to take impressions with the classical technique • Minimized impression errors	• It is an expensive technique • Requires extra equipment such as computer and software • Requires technical detail knowledge
Zirconium crowns	• Can be applied in a single session • It is more esthetic • Biocompatible • Can be sterilized • High durability • Alternative for those with nickel allergies • Biofilm formation is difficult on the crown	• Difficult to manipulate • Limited color options available • Technical precision required • Saliva and bleeding should be controlled • Difficult to apply in case of limited space due to crowding • It is expensive • Requires more tooth

		preparation than SSC
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2.9.8. Stainless steel crown restorations

Engel first produced stainless steel crowns (SSC) in 1950, but William Humphrey further popularized the use of crowns (334). A viewpoint was advanced in 1971 that recommended altering the stainless steel crown for severe cavities. Towards the end of the 1970s, the idea of using SSCs for space protection was put forward. In the early 1990s, Randy et al. added a loop to a stainless steel crown in order to use it as a band loop space maintainer. Early in the 1990s, Norma Hall also developed a method for restoring teeth with stainless steel crowns without removing caries (337).

Stainless steel crowns (SSCs) are prefabricated crowns that are used to restore extensive caries when multiple surfaces of the teeth were affected with caries lesions and teeth with developmental defects like molar incisor hypomineralization, hypoplasia etc., patients with oral parafunctions like bruxism, endodontically treated teeth (pulpotomy, pulpectomy) and patients who are in a high caries risk group, that are found in a variety of sizes. After preparing the tooth in accordance with instructions, these crowns are cemented with a biologically compatible luting cement (339). These crowns are, more commonly, the treatment of choice for high caries risk patients who are treated under sedation or general anesthesia (340).

The SSCs are made up of 12–30% chromium, 8% nickel, and 1–20% carbon. According to reports, SSCs last longer than amalgams (341).

The indications for the stainless steel crown are as follows (341);

- Teeth with a small amount of enamel after caries removal where adhesive bonding is not possible,
- Caries formation seen on more than one surface of the tooth,
- Patients with poor oral hygiene,
- Root canal treatment and amputation applied primary teeth,
- In the presence of dental anomalies,
- In fractures with excessive substance loss that can be seen in primary and permanent teeth,
- They can be applied in subgingival caries.

Stainless steel crowns (SSC) are advised by the American Academy of Pediatric Dentistry (AAPD) for the treatment of teeth with multiple surface caries. In high caries risk pediatric

patients, SSCs are advantageous treatment options to avoid secondary caries, have long term lifespan and support remaining dental hard tissue (342).

Recommendations of AAPD on SSCs (343);

1. For the management of dental caries in primary molars, SSCs are found to have a longer lifespan in comparison to dental amalgams and resin based restorative materials, as a result of retrospective studies. Particularly, when there is a need of advanced behavioral guidance, especially general anesthesia, to treat the patients with extensive multisurface caries, who are in the high caries risk group, SSCs are recommended.
2. For the permanent teeth affected by developmental defects or extensive caries, SSCs may be used as a temporary restorative alternative until the definitive restoration of the teeth can be performed.
3. There is a need for further investigation of assessing the success rates of conventional SSC application methods and HT.

While applying a stainless steel crown, it's critical to ensure marginal adaptation. Inadequately fitted crowns can harm the surrounding periodontal tissues and inhibit the emergence of the neighboring tooth. A poorly placed stainless steel crown might damage the neighboring tooth, resulting in serious malocclusion and caries (344).

There are studies stating that stainless steel crowns have a gingival compatibility problem or may cause periodontal problems. Tooth loss can also be seen in cases where the physician's clinical experience is insufficient or excessive preparations are made. Oral hygiene training is an important factor to ensure good periodontal health. A notable drawback of stainless steel crowns is their esthetic quality, which affects both the anterior and posterior deciduous teeth. Open-faced stainless steel crowns and veneered stainless steel crowns have been developed to overcome this disadvantage (345).

With the application of stainless steel crown restorations on a group of patients between the ages of 8 and 12, *Webber* (1974) noticed some gingival growth. He did note that the period of crown use has no significant impact on the gingival tissues and that the gingival differences in the mixed dentition may be physiological (346).

Sharaf and Farsi (2004) assessed the impact of stainless steel crowns placed on primary molars on bone and gingival tissues clinically and radiographically. Their findings demonstrated that gingivitis symptoms were present in crowns which were clinically considered to have poorly adapted margins. Patients who maintained good oral hygiene had healthy gingiva surrounding stainless steel crowns while those who maintained poor oral hygiene had a greater prevalence of gingivitis (347).

Hall Technique

Recently, a new technique to apply SSCs to decayed teeth has been introduced which is called the Hall Technique (HT) (348). With the help of this method, SSCs can be applied over the decayed primary molars without the need for tooth preparation, traditional caries excavation techniques and local anesthesia administration, which allows dentists to stop caries progression with a less invasive manner, by cutting of the contact of the bacteria in the biofilm with the caries lesion (349). Traditional drilling and filling methods may cause pain during local anesthesia administration and excavating caries lesions. On the contrary, discomfort caused by these procedures is minimized in HT (348). However, there is a need for applying separator bands in between contact teeth before SSC cementation which may also be the reason for feeling pain and discomfort of the patient. In addition to that, biting after placement of the SSC may cause pain. Still, HT can be considered as a treatment option for the uncooperative patients when traditional treatment methods cannot be applied (350).

Negative effects like pain and failure brought on by conventional therapy procedures are eliminated in individuals who receive treatment using the Hall technique. Due to the procedure's reduced pain and discomfort, it could be the treatment of choice (225).

Indications of the Hall Technique (348);

- In occlusal caries without cavitation, in cases where fissure sealant or conventional restorative treatments cannot be applied.
- In approximal caries with or without cavitation, in cases where fissure sealant or conventional restorative treatments cannot be applied.

Contraindications of the Hall Technique (348);

- In teeth with symptoms of irreversible pulpitis.
- In teeth that cannot be restored due to severe damage.
- Very young patients who don't cooperate with the procedure.

Advantages of the Hall Technique (351);

- It is a non-invasive treatment that does not require local anesthesia and conventional caries removal methods.
- Application time is short.
- It is less traumatic for children compared to other treatment methods.
- By covering the caries lesion, it slows down or stops the progression of caries.
- Its cost is lower than conventional methods.
- It can be applied in a single session.
- It helps in maintaining the health of the pulp.

The application of the hall technique in the treatment of teeth with asymptomatic carious lesions has been a controversial issue (351). In this treatment approach, the teeth are not prepared, they are restored with a stainless steel crown and the caries lesion is disconnected from the biofilm (339). However, *Innes et al.* (2011) conducted a randomized split mouth clinical trial to assess the clinical and radiographic failures of the SSC restorations using HT and compared with conventional restorations within a five year follow up period. Long term results showed that the success rates of using the HT exceeds the conventional restorative methods in clinical and radiographic examinations (352).

2.9.9. Zirconia crown restorations

Nowadays, stainless steel crowns are considered to be the most durable restorations that may be used for treating deciduous molars and can protect the tooth structure the most. SSCs have several advantages, but because of its aesthetic appearance, researchers continue to develop other materials. In order to overcome the aesthetic disadvantage caused by SSCs, zirconia crowns have been developed (337). Zirconium is a highly resistant structure against high temperature, wear and corrosion. The purity of zirconium metal increases its mechanical properties. It is known that zirconium began to be used as a biomaterial in 1969 with the construction of hip prosthesis by *Hellmer and Driskell* (353).

Zirconium crowns are prosthetic materials that are frequently used in adults. Recently, zirconia crowns suitable for clinical use in both anterior and posterior teeth have been developed for children. Zirconia crowns are available in prefabricated form for each tooth in 6-7 various sizes, similar to SSCs. A crown that fits the tooth size is chosen after caries have been cleaned up and the teeth have undergone occlusal and circumferential preparation. The last touches on the preparation should allow the crown to fit passively on the tooth (354).

The only difference between these two materials, in terms of indication criteria, is the esthetic considerations. The need for more aggressive tooth preparation and relatively less retention rates can be counted as disadvantages of zirconia crowns over SSCs. On the contrary, in terms of periodontal health, zirconia crowns are found to be more successful than SSCs (355).

Due to the high fracture resistance of the zirconium material, zirconium crowns are very strong. The prefabricated form of zirconium crowns released for children has been developed to be much stronger and more durable than the enamel structure. The transparency of zirconium crowns allows to solve the color problem that appears in the teeth after pulpal treatment (356). In a case study, *Cazaux et al.* (2017) presented the long-term results of one pediatric zirconia crown placed on an 8-year-old boy's primary mandibular right first molar. The patient had a

high risk of developing caries. There had already been a pulpotomy and a short-term glass ionomer restoration. The tooth needed a full-coverage restoration, and the aesthetic value of the restoration was very important to both the child and the parent. With a pediatric zirconia crown (EZ-Pedo, Loomis, California, USA), they restored the primary mandibular right first molar. Up to the patient's tooth's natural exfoliation, the patient was monitored for 29 months. Considerations included gingival health, attrition of the antagonist tooth, and adaptation of the pediatric zirconia crown. The long-term follow-up revealed that the gingival tissues were in good condition. At 29 months, there was gingival irritation surrounding the zirconia crown, however this inflammation was due to poor oral hygiene, as seen by the inflammation around the other teeth (357).

2.10. Dentistry in COVID-19 Pandemic

In December 2019, atypical cases of pneumonia of unknown etiology and rapidly spreading were seen in Wuhan, China's Hubei province. On January 8, 2020, it was stated by the Chinese Center for Disease Control and Prevention that the causative agent of atypical pneumonia is a new type of coronavirus (358). On March 11, 2020, the World Health Organization (WHO) declared Coronavirus Disease 2019 (COVID-19) to be a pandemic. The WHO China office received the initial report of this disease in December 2019 (359).

This disease caused by the coronavirus has spread rapidly, becoming a major public health problem not only for China but also for countries around the world. The World Health Organization International Health Regulations Emergency Committee declared the outbreak “a public health emergency of international concern” on January 30, 2020 (359). The effects of the COVID-19 pandemic have been observed worldwide. A population of 6.3 million people, including children, has been affected by the disease (360).

Transmission

The most common ways of transmission of SARS-CoV-2 from person to person are direct transmission by inhalation of respiratory droplets (cough, sneezing) and indirect transmission by contact with oral, nasal and eye mucous membranes (361). While symptomatic COVID-19 patients are the primary source of transmission, current research has revealed that SARS-CoV-2 is also carried by asymptomatic patients and others who are still in the incubation stage (362). According to reports, SARS-CoV-2 infections typically take 1 to 14 days to show. However, cases of the disease appearing 24 days after infection have also been noted (361).

SARS CoV-2 virus was shown to be infectious and capable of surviving for extended durations (up to a few days) on a variety of inanimate surfaces and floating in the air for up to 3 hours,

according to an experimental laboratory investigation (363). In another study using the virus culture method, live viruses were found in the saliva of individuals infected with SARS-CoV-2. Based on these findings, saliva may be a direct or indirect route of virus transmission (364). Considering the transmission routes of SARS-CoV-2 and the working principles of dentists, dentists, patients, and assistant personnel are at high risk for COVID-19 infection due to droplets and aerosols formed during dental procedures. In oral and dental health clinics, dentists and assistant staff are in close face-to-face contact with patients during dental procedures. It is known that droplets and aerosols contaminated with a large number of viruses spread to the environment during dental procedures. It is very hard to eliminate aerosol formation in clinics since these treatments frequently include the use of sharp, high-speed hand tools or ultrasonic devices. As a result, dentists are continually exposed to the saliva, blood, secretions from the respiratory system, and other contaminated bodily fluids of patients. The transmission of SARS-CoV-2 infection in dental clinics can occur in four different ways (365);

- Direct exposure to respiratory secretions containing droplets, blood, saliva or other patient secretions,
- Indirect contact with contaminated surfaces,
- Inhalation of airborne viruses, and
- Mucosal contact with infectious droplets and aerosols emitted by coughing and speaking.

Dentists should take the appropriate steps to protect themselves and stop the spread of COVID-19 by assuming that every patient who walks into the clinic is potentially carrying the disease (366).

Infection control protocols in dentistry practices (358);

- Hand hygiene
- Personal protective equipment
- Mouthwash use
- Radiographic imaging restriction
- Use of rubber-dam
- Clinical disinfection and medical waste management

Symptoms

Due to its widespread prevalence all over the world, the clinical features of the disease have been revealed very quickly. Common symptoms in people infected with SARS-CoV-2 are respiratory symptoms, fever, cough, and dyspnea. Symptoms such as muscle and joint pain, headache, sore throat, runny nose, weakness, smell and taste disorders and diarrhea can also be

seen. Although the disease can be asymptomatic, in severe cases, pneumonia, severe acute respiratory tract infection, kidney failure and even death may develop (367).

Loss of taste and smell have been reported in COVID-19 patients. In a cross-sectional study of 108 patients infected with SARS-CoV-2 in Wuhan, 46% of patients reported dry mouth as one of the symptoms of the disease, and approximately 50% experienced taste disturbance and loss of taste.³⁶⁸ Self-reported symptoms of loss of taste and smell are much stronger than self-reported fever in predicting a positive diagnosis of COVID-19. Loss of taste as an early symptom of COVID-19 before symptoms such as fever and cough appear supports the hypothesis that the oral cavity, especially the tongue mucosa, may be the first site of infection for SARS-CoV-2 (369).

Oral health

Many alterations in people's lives have been seen as a result of this new pandemic. As a result of the quarantines caused by the restrictions that came with the pandemic (370), children spent a long time at home, schools were closed and classes started to be held online. This situation had effects on children such as stress, anxiety, deterioration of nutrition and sleep patterns (371).

The daily routines of children have altered, which has resulted in an increase in eating frequency and calorie intake from the foods consumed during meals. Dental caries, as well as diseases like diabetes and obesity, are brought on by the increased intake of high-carbohydrate diets (372).

It has been shown that the influence of the days spent at home has a detrimental impact on the regular oral hygiene practices developed throughout the school season. *Ezzeldin et al. (2022)* found that sugar-containing foods were taken five times more often, and oral health problems developed threefold during the COVID-19 lockdown (373).

Routine control appointments are of great importance in maintaining oral health in children. Controls that are disrupted by the pandemic can adversely affect oral and dental health in children (374).

Recommended caries management techniques during COVID-19 pandemic

During the pandemic, the use of atraumatic, non-invasive or minimally invasive, non-aerosol-generating, or minimally aerosol-generating techniques has been recommended for safety reasons (375).

Sealants

Fissure sealant applications and additionally 5% NaF varnish applications are recommended by the ADA to stop non cavitated occlusal caries in primary and permanent teeth. In some studies,

a success rate of up to 10 years has been observed in teeth treated with this technique. For this reason, it is accepted as a method that can be preferred after the COVID-19 pandemic (376).

Silver diamine fluoride (SDF)

SDF is used to stop the progression of caries lesions in high-risk children, and to treat teeth in patients who are uncooperative during the application of traditional invasive caries removal methods or require special care. SDF applications are recommended by the ADA to stop and control cavitated caries lesions in primary and permanent teeth (376).

Atraumatic restorative technique (ART)

In populations with minimal or limited access to dental care, ART is a technique used to treat caries. It can be preferred in primary and permanent teeth. Higher chances of success were discovered, particularly in teeth with only one surface affected by caries. Applications of ART are therefore recognized as an efficient and secure technique that may be applied in the COVID-19 epidemic (377).

Interim therapeutic restorations (ITR)

Although ITR is technically similar to ART, it has a different purpose. Like ART, ITR does not produce aerosols. In order to prevent the progression of caries, it can be applied in younger patients who do not cooperate with conventional treatments and in patients who require special care, or in cases where treatments need to be delayed (1). It is a technique in which the caries is removed by using hand tools or slowly rotating instruments and the cavity is restored with glass ionomer cement. In a study by *Coll et al.*(2013), the effect of temporary ITR treatments on the pulp was examined. It has been observed that the application performed in a period of 1-3 months increases the chances of success in vital pulp treatments. Thus, ITR is another technique that can be preferred while treating caries lesions during Covid-19 pandemic (378).

The Hall technique

HT is a non-invasive technique used in the treatment of asymptomatic decayed primary teeth. It is performed by covering the tooth with a stainless steel crown in cases where the pulp is not affected by caries and the periapical tissues are healthy (379). It is a technique that does not produce aerosol. No preparation is made on the tooth. After waiting for three to five days following the placement of the orthodontic separator bands, the tooth is given adequate space for the placement of the stainless steel crown. It does not require local anesthesia application (335).

According to a review published by *Welbury* (2017), HT is a technique that can be applied quickly, does not require local anesthesia, has a high tolerance by children and is considered effective for the treatment of primary teeth (379).

According to a retrospective study by *Alamoudi et al.* (2022), an increase in HT and ART applications was detected during the pandemic period compared to the pre-pandemic period (380).

Considering all the advantages, including not producing aerosols, HT is a recommended technique to be applied during the COVID-19 pandemic (372).



3. MATERIALS AND METHODS

3.1. Ethical approval

This study was conducted with the approval of the Non-interventional Clinical Research Ethics Board of Yeditepe University. (202207Y0271)

3.2. Data collection

The patients who applied to Yeditepe University, Faculty of Dentistry, Department of Pedaitric Dentistry between January 2016 and December 2022 and were treated (general anesthesia included) and whose files were recorded in the hospital operating system were examined.

The information about the patients and the number of treatments were recorded in the hospital operating system (Figure 4) and were obtained by filling out the software request form (Figure 5).

667	05.07.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	D**** Ö***** Ö***** (PROF.DR.)	130725	B*** D****
668	05.07.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	D**** Ö***** Ö***** (PROF.DR.)	130725	B*** D****
669	05.07.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	D**** Ö***** Ö***** (PROF.DR.)	130725	B*** D****
670	10.07.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	N***** B****(DT.)	130137	S**** N** Y****
671	10.07.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	N***** B****(DT.)	130137	S**** N** Y****
672	11.07.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	D**** T***** (DR.)	130519	K**** Y*****
673	11.07.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	D**** T***** (DR.)	130519	K**** Y*****
674	11.07.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	D**** T***** (DR.)	129961	B*** T*** K*****
675	18.07.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	P**** A*** (ÖĞRENCİ)	126663	H***** N** S****
676	03.08.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	N***** B****(DT.)	128804	C**** Ö****
677	10.08.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	E*** Y**** D***** (ÖĞR.GÖR.DR.)	112790	K**** T**
678	14.08.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	D**** Ö***** Ö***** (PROF.DR.)	131659	E*** Y*****
679	14.08.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	D**** Ö***** Ö***** (PROF.DR.)	131659	E*** Y*****
680	14.08.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	D**** T***** (DR.)	131493	N** T*****
681	15.08.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	Z**** H***** (DOÇ.DR.)	130665	D**** G****
682	16.08.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	E*** Y**** D***** (ÖĞR.GÖR.DR.)	130843	E*** K****
683	04.09.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	D**** T***** (DR.)	124286	Y**** Ö*****
684	04.09.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	D**** T***** (DR.)	124286	Y**** Ö*****
685	04.09.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	Z**** H***** (DOÇ.DR.)	130742	C**** R*** A****
686	04.09.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	Z**** H***** (DOÇ.DR.)	130742	C**** R*** A****
687	04.09.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	Z**** H***** (DOÇ.DR.)	130742	C**** R*** A****
688	04.09.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	Z**** H***** (DOÇ.DR.)	130742	C**** R*** A****
689	06.09.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	E*** Y**** D***** (ÖĞR.GÖR.DR.)	131117	N***** A****
690	12.09.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	K**** T***** A**** (DR.ÖĞR.ÜYESİ)	131300	C** A** A****
691	14.09.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	A** S***** E**** (DT.)	131109	Y**** Y*****
692	19.09.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	E*** Y**** D***** (ÖĞR.GÖR.DR.)	122683	M***** N***** T****
693	25.09.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	D**** T***** (DR.)	130698	N***** N** Y*****
694	26.09.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	E*** Y**** D***** (ÖĞR.GÖR.DR.)	132592	S*** D*****
695	27.09.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	E*** Y**** D***** (ÖĞR.GÖR.DR.)	122683	M***** N***** T****
696	02.10.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	S**** S**** K***** (PROF.DR.)	132211	J*** S*****
697	09.10.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	S*** E*** (DT.)	92026	M***** E*** Z****
698	09.10.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	S*** E*** (DT.)	92026	M***** E*** Z****
699	09.10.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	S*** E*** (DT.)	92026	M***** E*** Z****
700	10.10.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	E*** Y**** D***** (ÖĞR.GÖR.DR.)	131805	O*** E** B*****
701	10.10.2018	PREFABRIKE PASLANMAZ ÇELİK KRON HİZMETİ	E*** Y**** D***** (ÖĞR.GÖR.DR.)	131805	O*** E** B*****

Figure 4: Recorded data of the patients' undergone SSC treatment

YAZILIM TALEP FORMU

Talep Edenin:			
Adı Soyadı			
Ünvanı			
Bölümü/Birimi			
E-Posta Adresi			
İrtibat Telefon Numarası			

Talep Şeklini seçiniz;	
☐ Yeni Yazılım Geliştirme	☐ Mevcut Yazılım Üzerinde Güncelleme / Değişiklik
☐ Hata Bildirimi - Kısa Süreli Yardım / Bilgi	☒ Data ve Rapor Talebi

Talep Şekli; Data ve/veya rapor talebi ise doldurunuz.	
Talebin Konusu	
Talebin Uygulamaya Geçilmesi İstendiği Tarih	
Talep Edilen Rapor/Data Başlıkları, Açıklamaları (Varsa Rapor Örneği Formatı)	
Rapor/Data Tahmini İhtiyaç Sıklığı (Her gün, Yılda bir vs.)	
Ekran Görüntüleri	
<i>Analist Veya Proje Sorumlusu Notu</i>	

NOT: Yazılım çalışmasını yapan personelin, Yazılım Geliştirme Talep Formunda (Ek belgeler dahil) belirtmediğim seçenekler için inisiyatif kullanmasını kabul ediyorum. Yukarıda belirtilen yazılım ile ilgili yapılan tercihler doğrultusunda gerekli geliştirme işlemlerinin yapılmasını arz / rica ederim.

Figure 5: Software Request Form

3.3. Patients included in the study

Patients who were treated with stainless steel crowns between January 2016 and December 2022 in the Yeditepe University, Faculty of Dentistry, Department of Pedaitric Dentistry were included in the study. While obtaining the data, no distinction was made about the conditions under which the treatment was performed, the age of the patients, and the systemic condition.

3.4. Statistical evaluation

The data obtained by requesting from the hospital operating system were categorized and recorded in the excel file according to the years and the clinic in which it was performed (Figure 6).

1	01.01.2016-31.12.2016			
2	Name - Surname	Protocol	Number of SSCs	Clinic where the procedure was performed
3	S**** S***** Ç*****	107823	4	Pediatric Dentistry Specialist
4	M**** Y**** A*****	81832	2	Pediatric Dentistry Specialist
5	E**** N*** Ş****	104045	4	PhD Student
6	E**** G*****	108809	2	Pediatric Dentistry Specialist
7	M**** M*** A*****	107954	1	PhD Student
8	M**** M*****	101136	1	PhD Student
9	T*** A***	98173	2	Pediatric Dentistry Specialist
10	E**** N** Ç*****	95338	2	Pediatric Dentistry Specialist
11	M***** D*****	110550	1	Pediatric Dentistry Specialist
12	H***** K**** U***	109164	4	Pediatric Dentistry Specialist
13	G***** S*****	110258	4	Pediatric Dentistry Specialist
14	M***** E** K***	110207	3	Pediatric Dentistry Specialist
15	B***** Z**** B****	101874	6	Pediatric Dentistry Specialist
16	U*** E***** İ***	109480	2	Pediatric Dentistry Specialist
17	A*** Ç**** A*****	111459	2	Pediatric Dentistry Specialist
18	S**** A**** Ö*****	7282	1	Pediatric Dentistry Specialist
19	K**** K****	107729	1	Pediatric Dentistry Specialist
20	H**** A*****	109220	2	PhD Student
21	E**** H***** Y*****	110037	2	PhD Student
22	Y**** K****	111171	2	Pediatric Dentistry Specialist
23	O*** K*****	112382	4	Pediatric Dentistry Specialist
24	E*** S*** B****	111245	1	PhD Student
25	A***** Ö*****	9500	2	PhD Student
26	G***** F**** K*****	111442	2	Pediatric Dentistry Specialist
27	Y***** D*****	112427	2	Pediatric Dentistry Specialist
28	T***** T**	97951	2	Pediatric Dentistry Specialist
29	D*** A*****	111529	2	PhD Student
30	S**** E**** S****	109245	2	Dental student

Figure 6: Categorization of the SSC treatments according to the clinic in which it was performed.

It was statistically analyzed whether there was an increase in the treatments and it was evaluated whether the pandemic had a statistically significant effect on the treatment. In addition, it was evaluated whether there is a significant difference between the SSC treatments performed in the clinic of the dentistry students, pediatric dentistry PhD students and specialist dentists in the Yeditepe University, Faculty of Dentistry, Department of Pedaitric Dentistry.

The data obtained in the study were analyzed using the IBM SPSS 22 (ver. 22.0, SPSS Inc, Armonk, NY, USA) program. The normality of the data in the study was determined with the Kolmogorov Smirnov test. The Kruskal Wallis test was used to analyze whether there was a significant difference between the numbers of SSC treatments performed by years. The Mann Whitney U test was used to assess the impact of the pandemic on the change in the number of SSC treatments. The examination of the difference between the treatments applied by dentistry students, PhD students and specialist dentists and the evaluation of the pandemic effect were made with the Kruskal Wallis test.



4. RESULTS

4.1. Analysis of the change in the number of SSC treatments by year

The Kolmogorov-Smirnov test was used to determine if the change in the number of SSC treatments over time conforms to the normal distribution, and the findings are displayed in Table 15.

Table 15: Determination of the normality of the SSC treatments performed each year.
(Kolmogorov-Smirnov Test (* $p < 0.05$))

Year	Statistics	Number of Treatments	p
2016	.311	141	.000*
2017	.274	148	.000*
2018	.303	91	.000*
2019	.280	170	.000*
2020	.279	103	.000*
2021	.295	185	.000*
2022	.253	261	.000*

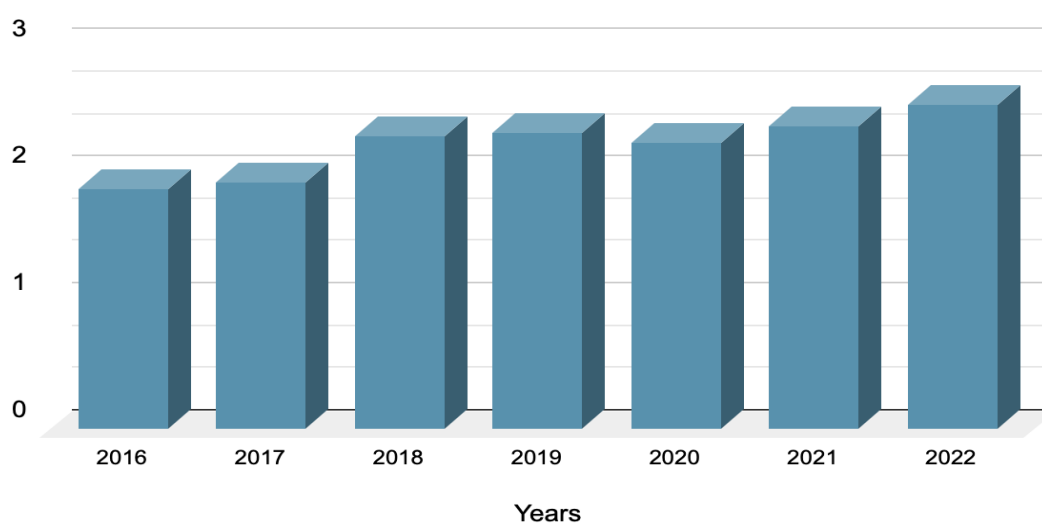
It was observed that the number of stainless steel crowns in each year between 2016 and 2022 did not follow the normal distribution ($p < 0.05$). As a consequence, the Kruskal Wallis test, one of the non-parametric tests, was used to determine if there is a significant difference in the number of stainless steel crowns by year, and the findings are displayed in Table 16. Considering the average number of stainless steel crowns, the least treatment was applied to 141 patients in 2016. The average number of applications in patients who underwent stainless steel crown treatment in 2016 is 1.89. In 2022, 261 patients underwent stainless steel crown treatments, which is the year with the highest rate among the years evaluated. The patients who were treated received an average of 2.55 stainless steel crown procedures (Graphic 17). When the results are evaluated, the number of stainless steel crowns has increased from 2016 to 2019, but this number has decreased relatively in 2020. As of 2021, the number of stainless steel

crowns has increased again. Statistically, a significant difference was found between the number of stainless steel crowns by year ($p < 0.05$). This difference found is between the stainless steel crown treatments performed in 2022 and the stainless steel crown treatments performed in 2016 and 2017.

Table 16: Analysis of the change in the number of SSC treatments by year (Kruskal Wallis Test, $*p < 0.05$)

Years	Number of the patients	Mean	SD	Median	Min	Max	χ^2	p
2016	141	1.89	1.35	2.00	1.00	12.00	16.264	.012*
2017	148	1.95	1.43	1.00	1.00	8.00		
2018	91	2.31	2.18	2.00	1.00	14.00		
2019	170	2.34	1.67	2.00	1.00	12.00		
2020	103	2.26	2.07	2.00	1.00	14.00		
2021	185	2.39	1.89	2.00	1.00	12.00		
2022	261	2.55	1.91	2.00	1.00	10.00		

Mean Value of Stainless Steel Crowns



Graphic 1: Mean values of stainless steel crown treatments

4.2. Evaluation of the effect of the COVID-19 pandemic in stainless steel crown treatments

The Kolmogorov-Smirnov test was used to determine if the quantity of stainless steel crowns performed before and after the pandemic corresponded to a normal distribution, and the findings are displayed in Table 17.

Table 17: Determination of the normality of the SSC treatments performed before and after COVID-19 pandemic (Kolmogorov-Smirnov test * $p < 0.05$)

	Statistics	Number of Treatments	p
Pre-pandemic	.295	594	.000*
Post pandemic	.269	505	.000*

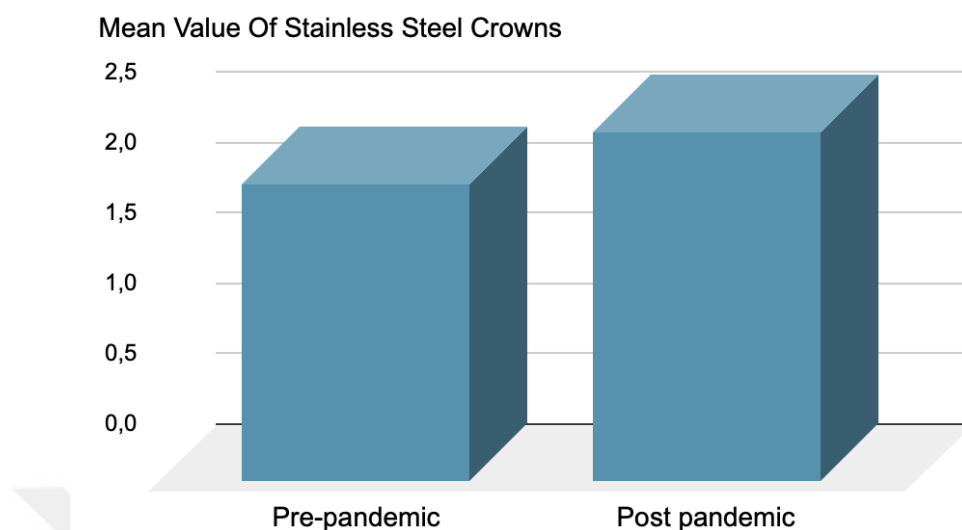
It was observed that the number of stainless steel crowns did not comply with the normal distribution in the pre- and post-pandemic period. Therefore, the Mann Whitney U test, one of the non-parametric tests, was used to determine whether there is a significant difference in the number of stainless steel crowns before and after the pandemic. The results are displayed in Table 18.

Table 18: Analysis of the change in the number of SSC treatments before and after pandemic (Mann Whitney U Test * $p < 0.05$)

	Number of the patients	Mean	SD	Median	Min	Max	Mann-Whitney U	p
Pre-pandemic	594	2.11	1.67	2.00	1.00	1.00	134106.500	.001*
Post pandemic	505	2.48	1.92	2.00	1.00	14.00		

594 individuals received an average of 2.11 stainless steel crown treatment before the pandemic. 505 individuals received an average of 2.48 stainless crowns following the pandemic (Graphic 2). At least 1 and at most 14 stainless steel crowns were applied both before and after the pandemic. A statistically significant difference between the stainless steel crown treatments

carried out before the pandemic's onset and the treatments carried out following the pandemic was discovered.



Graphic 2: Mean values of the stainless steel crowns before and after Covid-19 pandemic

4.3. Evaluation of stainless steel crown treatments performed in the clinics of dentistry students, PhD students and specialist dentists

The distribution of the number of patients according to the clinics where stainless steel crown treatments were performed is shown in Table 19.

Table 19: Number of the patients treated with stainless steel crowns

	Number of the patients	%
Dentistry Students	272	24.7
PhD Students	319	29.0
Specialist Dentists	508	46.2
Total	1099	100.0

The Kolmogorov-Smirnov test was used to determine if the quantity of stainless steel crowns corresponded to the normal distribution based on the clinics to which they were applied. The results are displayed in Table 20.

Table 20: Determination of the normality of the SSC treatments performed in each clinic (Kolmogorov-Smirnov *p<0.05)

	Statistics	Number of Treatments	p
Dentistry Students	.410	272	.000*
PhD Students	.292	319	.000*
Specialist Dentists	.258	508	.000*

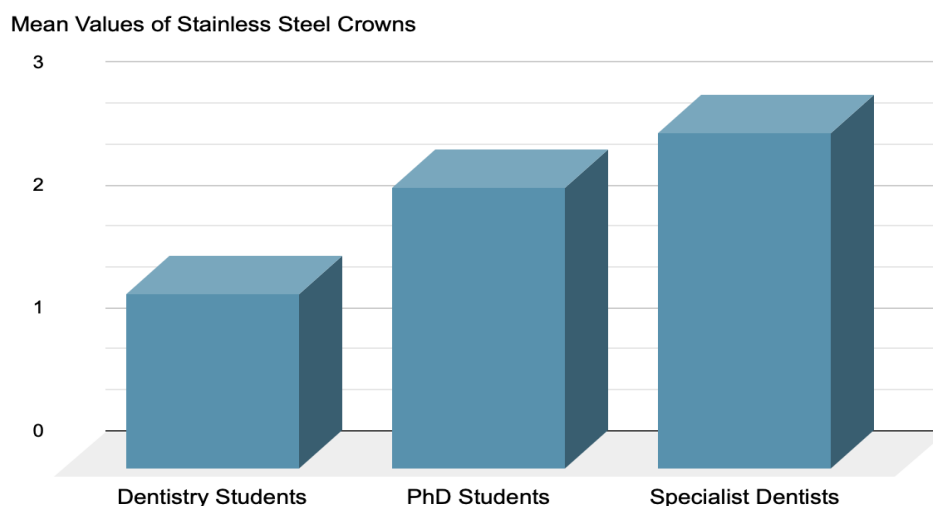
It was observed that the number of stainless steel crowns according to the clinics did not follow the normal distribution ($p<0.05$). As a result, the Kruskal Wallis test, one of the non-parametric tests, was used to determine whether there was a significant difference in the number of stainless steel crowns performed in each clinic. The findings are shown in Table 21.

Table 21: Analysis of stainless steel crown treatments performed in the clinics of dentistry students, PhD students and specialist dentists (Kruskal Wallis Test *p<0.05)

	Number of the patients	Mean	SD	Median	Min	Max	χ^2	p
Dentistry Students	272	1.42	0.73	1.00	1.00	5.00	123.261	.000*
PhD Students	319	2.29	1.78	2.00	1.00	14.00		
Specialist Dentists	508	2.73	2.04	2.00	1.00	14.00		

In the years evaluated, the highest number of stainless steel crown treatments were applied to 508 patients by specialist dentists, with an average value of 2.73. The least number of stainless steel crown treatments were performed on 272 patients with an average value of 1.42 stainless steel crowns (Graphic 3). Statistically, a significant difference was found between the number

of stainless steel crowns according to the clinics where the treatments were performed ($p<0.05$). The difference found is between PhD students and dentistry students and specialist dentists. In addition, there is a significant difference between the treatments performed by dentistry students and specialist dentists.



Graphic 3: Mean values of the stainless steel crowns in each clinic

The clinics underwent separate evaluations as before and after the pandemic. The stainless steel crown treatments performed by dentistry students, PhD students and specialist dentists compared with each other. The table provides a summary of the findings. (Table 22)

Table 22: Evaluation of each clinic before and after COVID-19 pandemic (Kruskal Wallis Test $*p<0.05$)

		Number of Stainless Steel Crown						Kruskal Wallis Test	
		Number of Patients	Mean	SD	Median	Min	Max	χ^2	p
Pre-pandemic	Dentistry Students	231	1.43	0.71	1.00	1.00	4.00	76.087	.000*
	PhD Students	122	2.48	1.98	2.00	1.00	14.00		
	Specialist Dentists	241	2.56	1.94	2.00	1.00	12.00		

Post Pandemic	Dentistry Students	41	1.32	0.85	1.00	1.00	5.00	43.888	.000*
	PhD Students	197	2.17	1.63	2.00	1.00	10.00		
	Specialist Dentists	267	2.88	2.12	2.00	1.00	14.00		

There was a significant difference between dentistry students and PhD students when examining the stainless steel crown procedures performed before the pandemic, as well as between dentistry students and specialist dentists. When the stainless steel crown treatments applied after the pandemic were examined, a significant difference was found between dentistry students and PhD students, between dentistry students and specialist dentists, and between PhD students and specialist dentists.

5. DISCUSSION and CONCLUSION

According to the data we obtained as a result of the study, an increase was observed in the stainless steel crown treatments performed in Yeditepe University Faculty of Dentistry, Department of Pediatric Dentistry until 2019. Although this number decreased with the restrictions brought by the pandemic effect, it increased again in 2022 with the normalization process. For this reason the H1 hypothesis has been met.

5.1. ECC

Early childhood caries (ECC) is a common health problem worldwide. It also adversely affects the general health of children, reducing their quality of life, reducing school attendance, and may cause aesthetic and psychological concerns. When dental caries is detected early, it can be stopped/reversed. However, in cases where treatments are unavoidable, treatment planning is made by considering the age and risk group of the child, the extent and depth of the caries, and the expectations of families and children from the treatment.

5.2. Etiology of ECC

ECC is a type of caries characterized by MS infection, which progresses rapidly and causes severe destruction (381). The etiology of ECC depends on many factors (382). These include environmental, behavioral, biological and socioeconomic factors (110). According to *Dye et al.* (2009), ECC is more common in children of low socioeconomic families and minority groups (382).

ECC etiology should also be evaluated in terms of microflora, diet, and host. Recent scientific studies have shown primary infection of *S. mutans* as the first stage in ECC development (383). *Becker et al.* (2002) compared the bacteria found in children with ECC and children without caries using molecular identification methods and observed significant differences in 9 species. While *S. sangius* was associated with healthy individuals, those associated with caries were *Actinomyces gerencseriae*, *Bifidobacterium*, *S. mutans*, *Veillonella*, *S. Salivarius*, *S. Constellatu*, *S.parasanguinis* and *Lactobacillus fermentum* (384). In addition to these findings above, *De Carvalho et al.* (2006), as a result of their microbiological evaluation studies on dental plaque and infected dentin samples of children with ECC, determined that *S. mutans* as well as candida species, especially *C. albicans*, were at high levels (385).

In addition to the importance of microflora, the effect of nutrition on caries development is great. The effect of breastfeeding on the development of ECC has been the subject of research.

According to the WHO, breastfeeding in infants is recommended up to 2 years of age with additional food supplementation from 6 months (386). The link between prolonged breastfeeding and the occurrence of dental caries is a controversial issue (387). Due to the risk of caries, the British Society of Pediatric Dentistry advised against prolonged breastfeeding in 2018 (388).

Olmez et al. (2003) evaluated the relationship between ECC-related factors and *S. mutans* in saliva, and evaluated the children of a total of 95 families with low socio-economic status in Ankara with ECC. It was found that 31.5% of them continued to use breast milk and bottle up to 37 months. While 40% of them are bottle fed, 35.5% of them are breastfed. 29.4% of them use both breast milk and bottle. They concluded that caries prevalence was significantly associated with age and eating habits (389).

According to a study by *Richard et al.* (2016), breastfeeding lasting less than 12 months was found to be effective in preventing caries formation. In comparison, children who continue to breastfeed for more than 12 months have a higher risk of caries.³⁹⁰ The result of this research is in parallel with the conclusions of a meta-analysis published by *Cui et al.* (2017) (391).

5.3. Prevalence of ECC

According to studies conducted on the prevalence of ECC, the prevalence of ECC between 2-3 years of age was 12-27%, while this value was found to be 27-48% between the ages of 4-6 (392). These results are in line with a study by *Tinanoff et al.* in 2019. In this study *Tinanoff et al.* (2019) proved that the incidence of caries increases with age. They found that while the prevalence of ECC was 17% in 1-year-old children, this value was more than 50% among 5-year-olds (393).

In the study of *Eronat and Koparal* in which they examined the caries prevalence of 500 Turkish children aged 2-13 years, the prevalence was reported as 34.6% and the average dft value was 1.08 for the 2-13 age group (394). In the study of *Kuvvetli et al.*, in which they investigated the prevalence of both non-cavitated and cavitated caries lesions in 300 Turkish children aged 5 years, the prevalence was found to be 45.7% and the mean dft was 1.93 for all caries types (395).

Uribe et al. (2021) reported that 48% of preschool children are affected by ECC. The evaluation was made on the basis of WHO criteria (396). Although lesions without cavitation are included in the definition of ECC, only cavitated lesions were evaluated according to these criteria in the study (397). As a result of the study, it was seen that ECC prevalence in Africa was less than the worldwide pooled prevalence, while Asia, Oceania, Central and North America were found

to be more than this value. It has been reported that prevalence in Europe is close to this estimated value. In addition to these findings ECC prevalence was found to be 60-90% among the indigenous people living in Australia, Canada and America (398-400).

5.4. Treatment of ECC

Protecting the health of primary teeth has a great effect on the general health status of children. During ECC treatments, the conservation of the tooth structure and the long-term clinical success of the restorations are among the important factors. In line with the studies carried out for this purpose, many materials have been developed for the treatment of primary teeth (401). In severe ECC cases, the quality of life of children is adversely affected. Therefore, the importance of protective applications has increased recently (402).

Ammari et al. (2007) investigated the effects of preventive practices in the prevention of ECC. As a result of the study, it was seen that the families who received oral health education individually provided better oral care for their children compared to the others (403).

Twetman et al. (2015) investigated the effects of individual and/or professional topical fluoride applications, fissure sealant applications, and antimicrobial agents in caries prevention in children up to 6 years of age. As a result of the study, they found that brushing the teeth regularly with fluoride toothpaste following the eruption of the first tooth is the most effective method (404).

Mishra et al. (2017) investigated the effectiveness of varnishes containing 1% and 5% fluoride in their study and reported that they provided 6.4-30% and 5-68% protection, respectively (405).

In cases where ECC cannot be prevented, treatment options ranging from follow-up of the carious lesion to extraction are available (406). If ECC is not treated, it progresses rapidly and causes destruction of dental hard tissues, pulpal and systemic symptoms (3).

Papathanasiou et al. (1994) evaluated the clinical success of different restorative materials. In this study, in which 604 restorations were examined in total, it was stated that the survival times of the applied restorations were SSCs, amalgam, composite resin and glass ionomer cement, respectively, from high to low. It has been reported that the mean survival time of SSCs and amalgam restorations is 5 years. In this period, the percentage of SSCs remaining in the mouth is 68%, and amalgam restoration is 60%. After four years, the success rate of composite resin restorations is 40% and the average residence time in the mouth is 32 months; It has been reported that the success rate of glass ionomer cement restorations is 5% and the average residence time in the mouth is 12 months (407).

5.5. SSC restorations

Stainless steel crowns (SSC) have been a frequently preferred treatment method in the treatment of primary teeth since 1950 (339). The use of SSC is increasing day by day in primary teeth that have been severely damaged by caries and have undergone pulp treatment (408).

With the popularization of SSCs, many studies have been conducted evaluating the clinical success of this treatment and comparing it with different restorative materials. The studies were carried out by evaluating different clinical conditions. Among these, there are clinical situations where one or more surfaces are affected by caries and different pulp treatments are applied.

Schüler et al. (2014) examined the clinical success of SSC treatment in children aged between 1.1 and 8.6 years. Criteria evaluated in the study included proximal contacts, marginal alignment of SSCs, plaque retention, and gingival bleeding. As a result of the study, the clinical success of SSCs was found to be 97.2%, regardless of the extent of caries and pulp treatment. It was observed that the vast majority of SSCs performed had subgingival margin compliance. No secondary caries were found in the examined teeth. It has been reported that gingivitis seen after SSC application is associated with inadequate oral hygiene (409). The result of this study is similar to the 95% success rate achieved by *Atieh et al.* (2008)(410).

Seale et al. (2015) published a systematic review investigating the performance of SSCs and concluded that SSCs demonstrated better clinical success as restorative treatment options for primary molars (339).

Innes et al. (2015) aimed to compare the clinical success rates and safety of all kinds of preformed crowns to traditionally used restorative materials like amalgam, GICs, compomers and composite resins, different crown placement methods, noninvasive caries management techniques and no treatment. This article has highlighted that, in contrast to traditional restorative materials, SSCs applied on decayed primary molars, with or without endodontic treatment, tend to cause less pain and have less failure rates in long term follow up periods. Also, using Hall Technique to apply SSCs, causes less pain and discomfort as opposed to traditional fillings. However, there had been little discussion about the quality and number of data for comparing SSCs and noninvasive treatment options (335).

AlMotawah et al. (2020) conducted a retrospective study on patients aged 2-6 years that were treated under general anesthesia. In this study, they compared the clinical success of restoring the caries lesion directly with SSC with the clinical success of restoring teeth with SSC after pulpotomy treatment. At the end of the 2-year follow-up period, there was no statistically significant difference between the two groups examined (411).

Wu *et al.* (2021) compared the effectiveness of the treatment of multi surface caries in pediatric patients treated with SSCs and intracoronal restorations. As a result of this study, SSCs had a 95.5 percent one-year survival rate and a 92.8 percent two-year survival rate, whereas intracoronal restorations had a 92.0 percent one-year survival rate and an 80.0 percent two-year survival rate. Overall survival analysis revealed that SSCs were considerably more effective than restorations, especially in children aged four years and younger. There was no statistically significant difference between children aged five and older who were treated. As the evidence suggested, SSCs have a greater survival rate and can be the treatment of choice for patients younger than four years of age for a long term successful treatment (412).

In addition to the high success rates achieved, nickel allergy is an issue that should be evaluated in the planning of SSC treatments. Allergic reactions seen after stainless steel crown application may cause different clinical pictures. The most common is allergic contact dermatitis in the area of contact with the material. More rarely, Systemic Nickel Allergy Syndrome (SNAS) may occur (413).

In a case report by Yilmaz *et al.* (2012), a 13-year-old boy receiving SSC treatment experienced an allergic response. The lesions healed spontaneously by replacing the SSC with a different restorative material (414). In a different case report published by Barcroft *et al.* (1997), the patient had SSC therapy and later developed ulcerative contact gingivitis. The lesion healed when the SSC was removed and replaced with a composite replacement (415).

Another issue to consider in SSC treatments is periodontal health. According to the results of the study published by Sharaf *et al.* (2004) on this subject, it was reported that SSC treatments, which were evaluated as clinically unsuccessful after radiographic evaluation, may lead to alveolar bone resorption, and the effect of proximal contacts on the gingival index is less than the effect of oral hygiene habits (347). The findings obtained as a result of this study coincide with the results of Myers' (1975) study (416).

Zagdwon *et al.* (2003) studied two ways of restoring permanent molars with developmental defects. These two methods included preformed SSCs and cast crowns. As a result of this study, there was no statistically significant difference between two methods in terms of the lifespan and quality of the restoration. However, prefabricated crowns were significantly less expensive and less time consuming than cast crowns. In contrast, cast crowns needed less preparation which meant more dental tissue was preserved. They claimed that choosing between these two methods depends on the short and long term demands of the patients individually (417).

5.6. Hall Technique

The Hall technique is a treatment performed by noninvasive application of SSCs to asymptomatic teeth. It can be preferred in patients with cooperation problems because it is more comfortable than conventional methods, does not require local anesthesia and can be applied in a short time.

Innes et al. (2006) examined the survival rate of SSCs performed by applying HT in decayed primary teeth. As a result of the study, they found that the treatments performed showed a survival rate of 73.4% at the end of 3 years and 67.6% at the end of 5 years (348).

Ludwig et al. (2014) retrospectively examined the clinical and radiographic success of SSCs applied with the conventional method and HT. As a result of the study, they found that 65 (97%) of 67 SSCs applied with HT and 110 (94%) of 117 SSCs applied with conventional methods were successful (418).

Elamin et al. (2019) achieved a success rate of over 90% for SCCs applied with HT and conventional methods in a study (419). These results are in agreement with the studies of *Ludwig et al.* (2014) (418).

Ayedun et al. (2021) clinically compared SSCs applied using the Hall Technique (HT) with SSCs applied using the conventional method. In the study, 25 SSCs were applied with HT and 25 SSCs were applied with the conventional method. Patients were followed up every three months for 12 months. When clinical success was evaluated, no statistically significant difference was found between the two methods. In addition, a significant difference was found between the two methods in terms of application time. In the study, while the average time for HT was 4.5 minutes, this time was found to be 28 minutes for the conventional method (420). In parallel with this result, *Innes et al.* (2006) found in a study that the time spent for SSCs administered with HT was 8.3. However, in some cases, orthodontic separator lastics may be required in cases where there is not enough space for SSC in the HT. This situation causes the need for an extra session to complete the treatment (348).

In addition to clinical success in treatments with HT, occlusion has also been a controversial issue. Accordingly, in a study conducted by *Innes et al.* (2007), it was determined that premature contact with the opposing tooth and an increase in occlusal vertical dimension were observed after SSC treatments using HT (351). No occlusion or temporomandibular joint (TMJ) problems were observed in the controls after 1 year. In another study by *Innes et al.* (2006) on this subject, it was determined that the changes in the occlusal vertical dimension healed spontaneously within a few weeks (348).

5.7. SSC versus Amalgam restorations

Although dental amalgams have been used as a restorative material in dentistry for many years due to their durability and longevity, in recent years it has caused controversy due to its mercury content, and its use in dentistry has decreased over time.

Einwag and Dunninger (1996) examined the clinical success of restoration with SSC and amalgam of teeth in which more than one surface was affected by caries. As a result of the 8-year follow-up period, they reported that SSCs have a longer lifespan and are a preferred treatment option in multi-surface caries (341).

Randall et al. (2000) concluded in a systematic review that SSCs have better results after applied to extensively decayed primary molars, than dental amalgams (421). In a review published by *Randall et al.* (2002), the failure rate of Class II amalgam restorations was found to be 2-7 times higher than that of SSCs (422).

Mata et al. (2006) examined the scientific dentistry literature on the primary dentition's use of stainless steel crowns (SSCs) vs amalgam restorations. To evaluate the use of amalgams and SSCs in the primary dentition, a thorough literature review of clinical trials was done (423).

Sonmez et al. (2010) examined the clinical success of amalgams and SSCs for the restoration of calcium hydroxide pulpotomy teeth. While the success rate of teeth restored with SSC was 79.9%, this value was 60% for amalgams. The success rate of SSCs was found to be statistically significantly higher than amalgams (424). The result of the study is similar to a study by *Gruythuysen and Weerheijm* (1997). In this study, the clinical success of restorations made with SSC and amalgam of teeth that underwent calcium hydroxide pulpotomy was examined and SSCs were found to be more successful. This was explained by the prevention of microleakage as a result of complete isolation of the tooth in SSC treatments and increasing the chance of success of pulp treatments (425).

Sigal et al. (2020) evaluated the clinical results and radiographic findings of SSCs and compared the outcomes with dental amalgams and composite resins on patients with special needs. The 10-year survival rates for SSCs were found to be 79.2%, while amalgam restorations' were 63.5%. They concluded that SSCs are a long lasting treatment choice for restoring permanent molar teeth (426).

SSCs outlast multi-surface amalgam restorations in terms of lifespan and retreatment requirements, according to scientific research. High-level evidence supports the use of SSCs because of their affordability, simplicity of application, and durability.

5.8. SSC versus GICS

GICs have been the material of choice for the treatment of primary teeth for many years. The fact that it can be applied to teeth where adhesive systems cannot be used, that cannot be adequately isolated, and that it is advantageous in children in the high caries risk group thanks to its fluoride release feature, has led to the widespread use of the material. However, it has some disadvantages such as low resistance to occlusal forces (427).

Roberts et al. (2005) compared the clinical success of SSCs with restorations made with RMGIC in a study. As a result of the 7-year follow-up period, a success rate of 98.3% in Class I cavities treated with RMGIC, 97.3% in Class II cavities, and 97% in SSCs was observed. There was no statistically significant difference between the treatments. As a result of the study, GIC restorations are recommended for small cavities, while SSCs are suitable for restorations of larger cavities (427).

Atieh (2008) examined the survival rates and clinical success of the SSCs and RMGICs using modified open sandwich technique. As a result of this study, significantly superior gingival health was seen for the teeth treated with RMGICs than SSCs. In terms of marginal integrity, secondary caries occurrence rates, occlusal fit and contact with proximal teeth, there was no significant difference between two treatment options (410).

5.9. SSC versus Compomers

Compomers are restorative materials obtained by combining the fluoride release properties of GICs with the mechanical properties of composite resins. Although their use in primary teeth is common, they show a lower success rate when compared to other restorative materials (428).

Korolenkova et al. (2019) investigated the efficacy of SSCs and compomers in pulpotomy treated teeth. SSCs showed statistically significant success when compared with compomers at the end of the 2-year follow-up period. As a result of the study, it has been reported that SSCs are a successful alternative, especially in the treatment of primary first molar teeth (428).

5.10. SSC versus Composite resins

Light-cured composite resins are one of the most preferred materials in the restorative treatment of primary teeth. The effect of the aesthetic properties of composite resins is great in the high rate of preference (429). In addition, the need for minimal caries removal as a result of bonding to the tooth with adhesive systems, its high resistance to abrasion and the support of the remaining tooth tissue are among the advantages of this material. Despite these advantages, the

success of the treatment may be adversely affected due to microleakage as a result of polymerization shrinkage. SSCs can be recommended to overcome some of the disadvantages of composite restorations (430).

Hutcheson et al. (2012) evaluated primary teeth restored with multi surface composite restorations and SSCs after being treated with white Mineral Trioxide Aggregate (MTA) pulpotomies. After a 12 month follow up period, there were no statistically significant differences between these two groups in radiological examination. They revealed that teeth which were restored with composite resins showed less marginal integrity than SSCs, however, this finding was not statistically significant. At follow up appointments, 94% of the teeth treated with composite material showed discoloration, nevertheless, this situation did not have a bad impact on the performance of the restoration and could be a result of using white MTA (431).

Chen et al. (2018) clinically evaluated the success of restoring teeth with pulpitis and periapical periodontitis with SSC and composite resins after endodontic treatment. In the data obtained as a result of the study, the failure rate of SSCs was found to be 5.4%, while this value was found to be 21.4% for composite resins. A significant difference was found between the 2 materials in terms of clinical success. In terms of marginal compatibility, restoration lifespan, and secondary caries development, SSCs were shown to be superior to composite resins. It is especially advised for treatment of children who are at high risk for dental caries (432).

Zahdan et al. (2018) investigated the clinical success of multi-surface composite restorations and SSCs applied by students. As a result of the study, the failure rate of SSCs was found to be 1.5%. On the other hand, the failure rate of composite restorations was determined as 21%. When the results obtained were evaluated, it was seen that SSCs had a higher success rate (433). These results are similar to the results of the study by *Papathanasiou et al.* (1994) (407).

Olegário et al. (2022) examined the 1-year survival rate of endodontically treated teeth after restoration with SSC and bulk fill composites. At the end of 1 year, the survival rate of bulk fill composites was 75%, while that of SSCs was 88%. In line with the results obtained, the success of SSC treatments was found to be significantly higher. Secondly, the study examined the rate of acceptance of materials by families and children. There was no significant difference between the two materials (434).

de Farias et al. (2022) studied the survival rates of SSCs and composite restorations in teeth affected by MIH. As a result of the research, the survival rate of SSCs was found to be significantly higher than composite restorations (435). These results are similar to the study by

Kotsanos et al. (2005), where they found a survival rate of 100% for SSCs and 74.6% for composite restorations (206).

5.11. SSC versus Zirconia Crowns

Although the clinical success of SSCs has been proven in studies, the lack of aesthetic properties is an important disadvantage of this material (436). This situation creates a prejudice against treatment in families and children. Zirconia crowns (ZC) produced to overcome this situation offer an aesthetic alternative (437,438). Although it has been used in adult patients for many years, zirconia crowns produced for children have been used since 2008 (439,440).

Abuelniel et al. (2018) examined the clinical and radiological success of primary molars treated with SSC and ZC. They also evaluated the gingival index (GI) and oral hygiene index (OHI) of the patients. At the end of 1 year, while SSCs showed a clinical and radiological success of 75.8%, this rate was found to be 80% in ZCs. When GI was evaluated, this value was found to be significantly higher for SSCs (441).

Mathew et al. (2020) compared the clinical success of teeth treated with ZCs and SSCs. They also evaluated the satisfaction of families and children with the treatment. As a result of the study, no significant difference was found between the two materials in terms of clinical success. In addition, less plaque deposition around ZCs has been reported. Considering the treatment satisfaction, only 40% of the families were aesthetically satisfied with SSCs, while this rate was found to be 100% for ZCs (442).

Agrawal et al. (2022) compared ZCs and SSCs in terms of retention, TMJ problems, plaque accumulation and periodontal health, and opposing tooth wear. Both materials showed 100% clinical success in terms of TMJ problems, while SSCs showed superior success in terms of retention periodontal health and plaque deposition and opposing tooth wear. The reason why ZCs are found to be unsuccessful in terms of periodontal health can be explained by the damage to the gingiva as a result of subgingival tooth preparation. This condition improves spontaneously over time with good oral hygiene (443). Unlike the results obtained in this study, *Abdulahdi et al.* (2017) found that less plaque accumulation was observed around ZCs (444).

Murali et al (2022) compared the clinical success of SSCs and ZCs. At the end of the follow-up period, the clinical success rate was 93.5% for ZCs and 96.7% for SSCs. These results showed that there was no significant difference between the two materials in terms of clinical success (445).

Studies have found differences in periodontal health and plaque deposition between SSCs and ZCs. In a study by *Sharaf and Farsi* (2004), poor compliance of SSC treatments with the

gingiva was associated with gingivitis seen after treatment. In addition, they emphasized the importance of oral hygiene education in terms of protecting gingival health (347). These results are in parallel with the results obtained by *Henderson et al* (1973) (446).

Abdulahadi et al. (2017) examined the effects of ZCs and SSCs on periodontal health in a study they conducted. The teeth were checked at the 3rd, 6th and 12th months. While better periodontal health was observed in the teeth treated with ZCs in the first 2 controls, there was no significant difference between the 2 groups at the end of the 12th month. This situation can be explained as the improvement of periodontal health with the oral hygiene education given to the patients (444).

Mathew et al. (2020) examined plaque deposition, periodontal health, and adhesion of *S. mutans* around SSCs and ZCs in another study they published. As a result of the 1-year study, more *S. mutans* colonization was detected on SSCs than on ZCs. This is explained by the different surface properties of dental materials. ZCs were found to be significantly more successful when looking at plaque accumulation and gingival health (441,442).

ZCs and SSCs were assessed by *Pei et al.* in a systematic review and meta-analysis in 2023. The study revealed that ZCs had reduced levels of plaque buildup and gingival index. Although ZCs are more successful in terms of periodontal health, it has been reported that they cause more wear on the opposing tooth than SSCs (447).

One of the biggest differences between ZCs and SSCs is the tooth preparation technique. In a study by *Clark et al.* (2016), they reported that ZCs require a more aggressive preparation compared to SSCs. Unlike SSCs, ZCs need to be passively seated during cementation and subgingival preparation is of great importance during tooth preparation (448).

5.12. Frequency of SSC Treatments

SSC treatments are becoming more and more popular due to reasons such as being durable, reducing the risk of secondary caries by providing good coverage, and providing anatomical form in cases where more than one surface is affected by caries and the structural integrity of the tooth is impaired.

SSCs are reported to be longer-lasting treatment options than dental amalgams and resin-based restorative materials in the treatment of teeth with developmental defects, carious teeth when multiple surfaces are affected, as well as the teeth of patients in the high caries risk group, in the pediatric restorative dentistry guide published by the AAPD in 2019 (449). In this regard, we examined SSC treatments in the pediatric dentistry department of Yeditepe University, Faculty of Dentistry, comparatively.

As a result of our study, in which the treatments performed between January 2016 and December 2022 were evaluated, it was seen that SSC treatment was applied at least in 2016 and at most in 2022 in terms of the average of the treatments. When the results of the statistical analyzes were examined, there has been an increase in the number of treatments between 2016 and 2019, while a relative decrease has been experienced in 2020. This decrease in the number of treatments in 2020 can be explained by the fact that in line with the measures taken in our country with the Covid-19 pandemic, treatments carried out by PhD students suspended until June, dentistry students took a break from clinical treatments between March and September, and specialist dentists apply only emergency treatments in this process. When the treatments applied by dentistry students, PhD students and specialist dentists were examined separately, it was observed that there was a significant increase in the clinics of specialist dentists compared to the treatments applied by dentistry students and PhD students. The reason for this can be considered as the fact that PhD students had been treating patients with a limited time and working in order on predetermined days with the measures taken to reduce the risk of transmission since June, when they started clinical practices again, and that the clinical studies of dentistry students who started treatment again in September continue among students who had accepted the risk.

Similar to those released by the AAPD, The British Society of Pediatric Dentistry (BSPD) has published papers to guide dentists in the treatment of primary teeth. These published papers have been prepared in line with the information obtained as a result of evidence-based studies (450,451). According to this guideline, SSCs have been recommended for the treatment of multi-surface and extensive carious lesions and pulp-treated teeth. However, when looking at the data obtained from the Dental Practice Board (DPB), it has been determined that general dental practitioners (GDPs) do not follow this guide. Although 25370 vital and 59512 nonvital pulp treatments were performed in the National Health Services (NHS) in 2002, only 3129 SSC treatments were applied (452).

In accordance with scientific research and clinical investigations, guidelines released by various associations provide light on the clinical practices of general and specialist dentists. Following published recommendations and being informed of most recent research is crucial for general and specialized dentists in order to achieve higher clinical success. *Threlfall et al.* (2005) conducted a study to examine the views of GDPs on SSCs in the treatment of primary teeth. As a result of interviews with 93 dentists, it was determined that 3 (3%) of the dentists participating in the study routinely used SSCs in their treatments, 14 (15%) rarely used them, and 76 (82%) had never used them before. In addition, it was questioned whether they heard the

recommendations regarding SSCs in the guide published by the BSPD. It was determined that 66 dentists (71%) heard the recommendations about SSCs, and 11 (17%) of these dentists had previously applied SSC treatment. Six (7%) SSC application, 79 (88%) GIC application, 2 (2%) extraction were reported as a treatment option for a case of primary tooth decay presented to dentists during the research. Among the dentists, 3 (3%) stated that they would not treat the teeth and would give oral hygiene education and nutritional advice. As a result of the research, it was found that the reason why the dentists did not apply SSC treatment was the high cost, the long time spent during the application of the crown to the tooth and the lack of cooperation of the patients (453).

A study was conducted by *Tickle et al.* (2007) to determine the variations in viewpoint between pediatric dentists and general dentists about the methods for treating young children's carious primary molars. During the study, dentists were presented with 2 different clinical scenarios and asked which method they would use to treat the tooth. In the first scenario, a clinical picture of a 6-year-old child with caries on the distal surface of mandibular first primary molar is presented. Among the dentists participating in the study, 1 out of 314 GDP (0.3%), 11 out of 107 pediatric dentists (10.3%) reported that they would treat teeth with SSC. In scenario 2, the clinical picture of a 6-year-old child with a larger caries lesion on the distal and occlusal surface of the primary molar tooth is presented. Among the dentists participating in the study, 5 of 318 GDP (1.6%) and 55 of 112 pediatric dentists (49.1%) reported that they would treat their teeth with SSC. As a consequence of the study, it was discovered that pediatric dentists and general dentists had different preferred treatment options in each clinical scenario. However, because extrinsic variables like the patients' and families' attitudes about treatment alternatives and clinical conditions at the time of treatment are not taken into account, the data collected at the end of the research do not reflect a statistically significant result. In addition to the preference of dentists, the aesthetic concerns of families also come to the fore in SSC treatments. In some studies, one of the reasons why dentists do not prefer SSC in large caries lesions was found to be the preference of families and children for aesthetic alternatives. Besides that, it has been seen that families' ideas may change if the advantages of SSCs are explained to the families (454).

On the other hand, when considering the years evaluated in our study, the effect of the COVID-19 pandemic on the treatments applied was also examined. As a result of statistical analyzes, it was determined that there was a significant increase in stainless steel crown treatments after the beginning of the pandemic, and the highest increase was in 2022. This result is similar to the study by *Alamoudi et al.* (2022), in which they observed an increase in stainless steel crown

treatments performed by applying HT in the post-pandemic period (380). Since there is no preparation process in stainless steel crowns applied using HT and aerosol production is reduced to a minimal level compared to the rotary instruments, it has been accepted as a safe method during the pandemic process and the frequency of its application has increased.

5.13. Limitations

The study's objective is to assess the changes in the number of stainless steel crown procedures carried out at Yeditepe University, Faculty of Dentistry, Department of Pediatric Dentistry through time in light of recent research and published guidelines. The pandemic had a significant impact on treatments performed throughout the study's time period. With the onset of the pandemic, standard patient treatments were temporarily suspended, and only emergency interventions, like extractions, pulp extirpations, and medication prescriptions were made. Dentistry students could not perform clinical applications for a while. This has led to a decrease in the number of treatments performed in the dental hospital during this period. For this reason, it was observed that there was a decrease in the number of treatments in the data flow obtained. The changes made in the clinical setting with the measures taken due to the COVID-19 pandemic, which has a wide impact worldwide, and the disruption of the treatments to be made can be considered as the limitation of the study. However, the research area was expanded by adding the evaluation of the effect of the pandemic to the stainless steel crown treatments.

5.14. Conclusion

Caries formation is a phenomenon that occurs when the balance between protective factors and cariogenic factors shifts to the negative direction. After the first tooth erupts, infants should begin receiving oral and dental care. Otherwise, caries development occurs with the predominance of cariogenic factors. The effect of primary teeth on oral and systemic health, nutrition, speech development, jaw development and permanent dentition in children is an undeniable fact. For this reason, prevention of caries formation and early diagnosis and treatment in case of caries development are of great importance.

There are many treatment alternatives for caries in primary teeth in children. These vary from local fluoride applications, which are among non-invasive treatments, to treatments in which structural integrity is regained with different restorative materials after cleaning the caries with invasive methods such as mechanical/chemo mechanical/laser caries removal techniques. Many factors should be taken into account when deciding on the treatment to be performed. These include the depth and extent of the caries lesion, the age and cooperation of the child, and the

expectations of the families. In addition, it is of great importance whether the tooth has undergone endodontic treatment or not, while deciding the type of the restorative option. A durable and leak-proof restoration is crucial for the success of endodontic procedures. At this point, stainless steel crowns have a clinically proven high chance of success compared to glass ionomer cements and resin-containing restorative materials. The tooth is completely encircled by stainless steel crowns, which offer good coverage, lower the risk of secondary caries, and enhance the success rate of endodontic treatment. In addition, it restores the structural integrity of teeth with large caries lesions, where more than one surface is affected by caries, increases the resistance of the tooth against occlusal forces, and ensures that the deciduous teeth maintain their position in the mouth until the eruption of the permanent teeth. According to the findings of the studies, stainless steel crowns are recommended as a treatment option more often than resin-containing restorative materials, particularly in teeth with developmental defects, large carious lesions, and teeth that have undergone endodontic treatment. In accordance with the findings of our study, there was an increase in stainless steel crown treatments up until the COVID-19 pandemic, which disrupted clinical applications. Following the decline in treatments seen in 2020, a rise was found once more in 2022 as the pandemic's impact decreased.

5.14.1. Highlights

- The health of primary teeth is of great importance for the growth and development of children, as well as for the development of permanent teeth.
- If the necessary preventative measures are followed, tooth decay is a disease that may be prevented.
- In the treatment of primary teeth, there are noninvasive and invasive treatment options that can be applied when the width and depth of the caries, the age of the child, the expectations of the family and children are evaluated.
- Due to their higher clinical success, stainless steel crown treatments are advised for the treatment of endodontically treated teeth that have extensive caries lesions and developmental defects.
- Dentists should follow the current literature and target more successful treatments with the knowledge gained from evidence-based dentistry in clinical practice.

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7. APPENDICES

7.1. Ethical Approval



No : E.83321821-805.02.03-53
Subject : Non Interventional Clinical Research
Ethics Board Decision

To Prof. Dr. Didem Özdemir Özenen

Yeditepe University Non-Interventional Clinical Research Ethics Board has reviewed the research proposal placed upon ethical approval for the project as the research title, the researchers, the application number, the ethics board meeting details, and the provided documents have been outlined below. This research proposal has been evaluated by the members of the ethics board and full ethical **APPROVAL** has been granted.

Research Title:	Frequency of stainless-steel crowns use to restore primary molars: a retrospective study
Researchers:	Ayşe Sultan Elmas, Prof. Dr. Didem Özdemir Özenen
Application Number:	202207Y0271

ETHICS BOARD MEETING DETAILS			
Meeting Date:	12th August 2022	Meeting Place:	Online (Google Meet)

PROVIDED DOCUMENTS	
Wet signed application file, file uploaded to a CD or USB media, and electronic submission	
Title of research and the names of the researchers	
Letter of application	
Application Form	
Nature of the Research;	
• Type	
• Significance and distinctive value	
• Aims and objectives	
• Method	
• Management of the research	
• Widespread impact	
• Pertinence of the budget and reason (if applicable)	
• Timeframe and convenience	
• References	
Informed consent form (uniquely prepared for the research)	
Letter of Undertaking-1	
A commitment to undertake the responsibility of obtaining institutions permission from where the data collection will be made	
Letter of Undertaking-2	
A commitment to read the latest version of the World Medical Association Declaration of Helsinki and all relevant guidelines of the Ministry of Health	

True copy by e-signature.

Document Tracking Address : <http://belgedogrulama.yeditepe.edu.tr/bg.aspx?id=7D8AE5C2-CCD7-4A39-BA0B-246A792B4154>

Yeditepe Üniversitesi 26 Ağustos Yerleşimi, İnönü Mahallesi Kayışdağı
Caddesi 34755
Ataşehir / İSTANBUL
Telefon No: (0216) 578 00 00 Faks No : (0216) 578 02 99
İnternet Adresi www.yeditepe.edu.tr
Kep Adresi : yeditepeuniversitesi@hs03.kep.tr

For Info: Sinem ARI

Profession: Uzman Yardımcısı

Phone Number:



Letter of Undertaking-3 A commitment on whether there are previous ethical board applications
Letter of Undertaking-4 A commitment that no action will be taken during the research that is not included in the research budget and that will bring additional burden to the volunteer or the Social Security Institution
Letter of Undertaking-5 A commitment to reading the circular on treatment approaches and scientific research in COVID-19 patients
Letter of Undertaking-6 A commitment to reading the document of Research Application Permissions that is published by Ministry of Education
'Resume Forms' filled separately by all the researchers and signed
Additional documents (Scale permissions used, if any, etc.)

Doç. Dr. Elif SUNGURTEKİN
EKÇİ
Raportör

Doç. Dr. Mehmet Engin CELEP
Üye

Doç. Dr. Binnur OKAN
BAKIR
Üye

Assist. Prof. Dr. Elif Çiğdem KELEŞ
Member

Dr. Öğr. Üyesi Emine Nur
ÖZDAMAR
Üye

Dr. Öğr. Üyesi Sevim ŞEN
Üye

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Yeditepe Üniversitesi 26 Ağustos Yerleşimi, İnönü Mahallesi Kayışdağı

Caddesi 34755

Ataşehir / İSTANBUL

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Phone Number:



8. CURRICULUM VITAE

Personal Information

Name:	Ayşe Sultan	Surname:	AGİN
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Educational Background

Degree	Branch	Graduated From	Graduation Year
Undergraduate / Postgraduate	Dentistry	Yeditepe University	2019
High School	-	Turgutlu Halil Kale Fen Lisesi	2013

Foreign Languages	Foreign Language Testing Score
English	YÖKDİL 96,25

Computer Skills	Technical skills
Microsoft Office	Good