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# The risk of tooth erosion due to consumption of carbonated beverages

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## Abstract

Dental erosion, also known as erosive tooth wear, is a condition in which dental hard tissue is continuously lost and chemically etched away from the tooth surface without the presence of microorganisms. Acidic beverages are well-known for being a significant extrinsic cause of tooth erosion. Since the pH of the majority of these soft drinks is in the range of 2, oral bacteria can also ferment the sugars in soft drinks and produce acids. The naturally occurring acids and sugars have the potential to be both acidogenic and cariogenic, leading to dental caries and possible enamel loss. This study aims to review the literature on the risk of tooth erosion due to consumption of beverages. This review discusses the etiology of dental erosion related to acidic or beverages drinks and the risk factors influencing the incidence of dental erosion. The review also examines the pattern of erosion related to how often the dental tissue is exposed to acidic fluid. Dental hard tissues are negatively impacted by current changes in drinking habits. Dentists are concerned about soft drinks. In order to prevent dental erosion, patients must be informed about the negative effects of excessive soft drink use and are encouraged to select a low-erosive beverage, such as a non-carbonated soft drink.

**Keywords:** Dental Erosion; Soft Drinks; Dental Health; Produce Acids

## 1. Introduction

Dental erosion is the permanent loss of dental hard tissue brought on by a chemical reaction that doesn't include any microorganism. Extrinsic or intrinsic agents may be the cause of dental erosion. Recurrent vomiting as a symptom of eating disorders like anorexia or bulimia nervosa or as a result of regurgitation of gastric contents are examples of intrinsic causes. Acidic chemicals, drinks, food, medications, and environmental exposure to acidic agents are examples of extrinsic causes [1]. Between 20% to 41% of children and adolescents worldwide have DE of their permanent teeth [2]. As over 80% of the global population is afflicted, dental caries, commonly known as tooth decay or cavities, is a rising essential oral health issue. All populations on earth and the disease are widely infected. When compared to 2008, it is expected that consumption of sugary drinks grew by 62% in 2018. 90% of adults over 20 were found to have dental caries. The likelihood of acquiring dental erosion increases with the consumption of carbonated beverages. Compared to young children and elderly populations, young adults consume more carbonated beverages. The kind of carbohydrate, the amount and frequency of consumption, dental care, fluoride exposure, and pit and fissure sealants all have an impact on cariogenicity. Given that they contain additional sweets, carbonated beverages are regarded as a typical source of dietary sugar. Compared to ingestion during meals, exposure to sweets more frequently between meals is associated with increased caries activity [3].

There are numerous risk factors for tooth erosion. Oral health is impacted by diet and nutritional variables in a variety of ways [2]. Carbonated beverages, still and juice drinks, dilutables, fruit juices, bottled waters, sports and energy drinks are examples of soft drinks. According to the British Soft Drinks Association Annual Report (2016), there was a 0.2%

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increase in overall soft drink consumption in the UK between 2010 and 2015. More than half (58%) of the soft drink consumption in 2015 was of the no-calorie or low-calorie variety (0-20 kcal per 100 ml), up from 13.2 billion liters in 2010. Some soft drinks may be detrimental to people's dental and overall health, particularly young children and teenagers. The high concentration of sugar and acids, which have the potential to cause dental caries and tooth erosion as well as other health problems including overweight and obesity and a possible increased risk of type 2 diabetes, can also contribute to dental caries and tooth erosion [4, 5, 6].

Because carbonic acid, phosphoric acid, and citric acid are added to carbonated beverages to enhance flavor, they naturally contain these acids. The taste is improved and the sweetness of the carbonated drinks is offset by the carbonic acid that is created when carbon dioxide dissolves. Even after the carbon dioxide has been expelled, additional acids like citric acid and phosphoric acid contribute to the low pH level. The erosive potential of a carbonated drinks is also influenced by a number of other variables, including the buffering ability, chelation ability, frequency, and length of ingestion. Additionally, pretreatment of the tooth tissue and the beverage's calcium, phosphate, and fluoride levels appear to be significant determinants of the relationship between carbonated drinks and dental erosion [2].

Previous research has indicated that teenagers who consume two or more cups of carbonated beverages per day are two- to three-times more likely to experience oral health consequences (AOR = 2.41, 95% CI = (1.11-5.26)). Additionally, among young individuals, fizzy drink consumption was associated with an increased risk of tooth loss (OR = 52.81.95%CI = (51.37-5.76)) [3]. In this study, we review the literature on the risk of tooth erosion due to consumption of beverages..

### 1.1. Dental Erosion

Dental erosion is the permanent loss of dental hard tissue brought on by a chemical reaction that doesn't include any microorganism [1]. Dental erosion is the permanent breakdown of dental hard tissues caused by a chemical reaction without the presence of microorganisms. Dental erosion (DE) is the irreversible chemical process that results in the loss of dental hard tissues without bacterial involvement [2]. It is a multifactorial disorder that is causing significant concern. It frequently coexists with other types of tooth wear, such as attrition from contact between teeth and abrasion from any substance with an abrasive effect [7].

### 1.2. Epidemiology of Dental Erosion

When poor oral health is mostly preventable, dental caries is the most frequent reason for children aged 5 to 9 to be referred to hospitals in the UK. Nearly 46,500 children and teenagers under the age of 19 were hospitalized in England in 2013–2014 with a main diagnosis of dental caries, with children aged 5 to 9 accounting for more than 55% of cases. From 2010 to 2011, this number climbed by 14%, and it keeps rising each year [4]. Due to changes in dietary, behavioral, and hygiene practices during the past ten years, there has been a marked rise in the prevalence of dental erosion in the young population. With incidence rates ranging from 1.8% to 34.1%, this has led to an increase in non-caries lesions, notably with regard to dental erosion, which mostly affects the palatal surfaces of maxillary anterior teeth and the occlusal surfaces of mandibular first molars [8].

With rates ranging from 7.2% to 95%, the prevalence of dental erosion in children and adolescents around the world exhibits significant diversity. 30% of children and teenagers with permanent teeth, aged 8 to 19, have tooth erosion. According to reports, between 24 and 64 percent of young people in European countries and between 12 and 75 percent in Scandinavian countries suffer dental erosive wear. Dental erosion seems to get worse over time and increase with age. A longitudinal study from the UK on a group of 12-year-olds found that over the course of the study's two years, 27% of the children developed new or more advanced lesions. Another three-year longitudinal research among a group of 10 to 12 year olds in the Netherlands revealed a consistent progression of dental erosion [7].

### 1.3. Etiology of Dental Erosion

The causes of erosion are complex and include biological (general health, teeth, biofilm, acquired pellicle, and saliva), chemical (saliva buffer capacity, pH, type of acid, presence of calcium, fluoride, and phosphorous), and occupational (occupation, drugs, oral hygiene practices, and eating disorders) factors that can affect the frequency and severity of erosive wear [8]. The causes of DE can be categorized as "external" and "internal" causes. The consumption of particular foods, certain medications, and conditions relating to the workplace are examples of external causes. The main exogenous causes of DE in today's children are a lifestyle that includes eating more fruits and vegetables, drinking sports drinks while exercising, but especially consuming more fruit juices and soft drinks. Both a healthy and unhealthy lifestyle can increase a person's susceptibility to erosive wear. Internal factors can include disorders like gastroesophageal reflux disease (GERD), which causes vomiting on a regular basis, or illnesses like eating disorders.

There may be reflux illness even in the absence of personal symptoms and should always be suspected in idiopathic dental erosion. Nearly 8.5 times as many people with eating problems have DE [1, 7]. Asthmatic patients who regularly inhale vapors that primarily contact the palatine surfaces of the teeth while using medications that have a low pH and come into direct contact with the tooth surface may exhibit erosive potential, among other things [8].

### 1.4. Dental Erosion Manifestation

A smooth, dull, transparent surface, an intact enamel edge in the gingival margin, the absence of dental morphology, the presence of depressions and concavities in the surfaces, the presence of overlying restorations, and in severe cases, the lesions' potential to affect the dentin and pulp are all clinical characteristics of erosive lesions [8]. Lesion can certainly be thought of as the outcome of an acid challenge since erosion, attrition, and abrasion are difficult to identify in their early stages. This is supported by their placement and form. According to the investigations, the clinical diagnosis of DE was reached on the basis of a recognized departure from the original anatomical tooth morphology brought on by acid-induced tissue loss. The first symptom is a smooth, silky, shiny, glazed surface that is coronal to the cementoenamel junction and is present in the region of the smooth, non-functional occlusal and incisal surfaces. In a later stage, flat sections with a breadth that is obviously greater than its depth become visible, and finally, the original tooth morphology is significantly altered [2].

### 1.5. Mechanism of Dental Erosion

The leading cause of disease in both industrialized and developing nations is dental caries. The etiology is complex and involves multiple factors, including socioeconomic status, behavior, genetics, management of oral pH, bacterial colonization and adhesion, physical and chemical characteristics of the tooth, time, carbohydrate intake, and lifestyle. Both internal and extrinsic sources can produce acids. These are thought to be some of the key reasons why teeth erode. Low pH acidic foods and beverages are a major factor in the development of erosion. However, erosion cannot be brought on by a food substance's pH on its own. The presence of calcium, phosphate, and fluoride; behavioral factors such as eating habits, lifestyle, and excessive acid consumption; and biological factors such as flow rate, buffer capacity, saliva composition, tooth composition, and soft tissue anatomy are additional factors that contribute to the erosive process. However, the primary contributor to the clinical implications of tooth erosion may be the interaction of the aforementioned elements with the abrasion process, namely as a result of poor oral hygiene habits [9].

Dental erosion is the irreversible acidic chemical disintegration of tooth surface structure when there are no bacteria present. Proton-promoted dissolution is the phrase for what happens when hydrogen ions [H+] after diffusing through the plaque-pellicle biofilm interact with the surface fluorapatite and hydroxyapatite crystals. However, with continued erosive insult to the surface enamel, larger regions of the enamel-dentin junction may eventually become exposed, leading to heightened sensitivity. Erosion may first progress through the enamel lamellae exposing dentinal tubules and causing dentinal sensitivity. The tooth surface erodes as the pH of the oral cavity falls below 4.0, and as the pH decreases by units, enamel solubility increases tenfold, leading to a 100-fold increase in demineralization as the pH approaches 2.0 from 4.0. Importantly, drinking liquids with higher levels of accessible hydrogen ions (pH 4.0) causes the tooth surface to immediately soften, making it far more vulnerable to erosion by abrasion and attrition.Due to their thinner enamel coating, deciduous teeth are more vulnerable to fast dentin erosion that exposes the tooth pulp. It is obvious that erosion leads to a variety of clinical issues, necessitating restorative procedures to restore aesthetic function, replace lost tooth structure, and get rid of dental pain [10].

### 1.6. Carbonated Beverages

Carbonated soft drinks are the most frequently consumed sweetened beverage in America for the previous 35 years, with children, adolescents, and young adults making up the majority of consumers.Lime juice concentrate has a pH of 2.1, spring water has a pH of 7.4, and so do commercial non-dairy beverages. Drinks sold commercially that have a pH under 4.0 may harm the teeth. Drinks are given an individual flavor by the addition of acids, which create a flavor profile. Acids are essential to the flavor of the beverage since they give it an acidic and tangy taste that counteracts the sweetness of the sugar it contains. In order to provide tartness, slow the growth of germs and fungi, and extend shelf life, phosphoric acid is added to cola drinks. Citrus drinks naturally include citric acid, which is also added to many other beverages. It serves as a preservative and adds a sour flavor. Because it enhances the inherent flavor, malic acid, which is found naturally in apples, pears, and cherries, is added to many non-carbonated drinks like fruit drinks, fortified juices, sports drinks, and iced teas. Malic acid is added to carbonated drinks that have been artificially sweetened in order to enhance flavor and lessen the number of additional flavorings. The beverage's characteristic sugar/acid hallmark flavor is provided by these additions [10, 11, 12].

Several of the other ingredients in soda water include [13, 14, 15, 16]:

- The main component of carbonated soft drinks is water. Compared to diet soft carbonated beverages, which can contain up to 98% water, conventional soft drinks typically include about 90% water. Additionally, it serves as a carrier and solvent for other substances.
- A colorless gas with a density greater than that of regular air is carbon dioxide (CO2). The only gas that may give soft carbonated drinks effervescence is carbon dioxide. Additionally, carbon dioxide acts as a preservative by inhibiting the development of microorganisms like yeast, mold, and lactic acid bacteria. Additionally, it works to increase internal pressure inside the cans, which prevents shape deformation.
- Substances used to sweeten beverages, particularly those other than sugar, are known as sweeteners. The main components (8–12% w/v) in the production of soft carbonated beverages are sweeteners. Chemically, carbohydrates—a group of incredibly diverse chemical compounds found in both plants and animals—are the main sweeteners in soft carbonated drinks. Bulk sweeteners and strong sweeteners are the two broad categories into which sweeteners can be divided. Bulk sweeteners are utilized when the structural and sensory qualities of food are necessary since sugar has a number of physical properties that contribute to these requirements. Sugar also provides sweetness. Sugar alcohols (such as maltitol, sorbitol, erythritol, mannitol, isomalt, lactitol, and xylitol) make up the majority of bulk sweeteners. To achieve certain flavor profiles, sweetener blends (such ace-K/aspartame) can also be utilized, especially in soft drinks. When used, they may produce a different "mouth feel" from sugar. Aspartame, for example, is a strong sweetener that is metabolized during digestion; sucralose, on the other hand, is not metabolized and is expelled intact.
- There are three types of flavors: natural flavors, flavors that are equivalent to those found in nature, and synthetic flavors.
    - Natural flavors, including volatile oils and diverse plant or animal extracts. Flavors that are chemically separated or synthesized but are identical to substances that occur in nature are known as "nature identical flavors."
    - Flavorings that are synthetic or artificial and do not appear to be natural. They are accessible and less priced.
- Acidulants. Food additives known as acidulants give carbonated beverages their sour, tart, or acidic flavors. The choice of an acidulant is influenced by a number of variables, including pH, hygroscopicity, solubility index, and flavor character (desired sharpness).
- Color. In terms of food, color has significant implications since, combined with flavor and texture, color greatly influences how food is perceived and tasted.
- Preservatives. By preventing the development of microorganisms, preservatives extend the shelf life of soft carbonated beverages. Making soft carbonated beverages safe for human consumption is the primary purpose of the preservative. In soft drinks, preservatives such sorbic acid, sorbates, sulphur dioxide, sulphites, parabens, benzoic acids, and benzoates are frequently utilized.
- Stabilizers are compounds used to preserve the dispersion of fruit solids in carbonated beverages and to stabilize emulsions. These increase viscosity, which enhances the mouthfeel qualities of carbonated beverages. These include gums made from plants, carrageenans, pectin, acacia, xanthan, alginates, and carboxymethyl cellulose. Quillaia extract is used in carbonated drinks as a stabilizer and for its foaming qualities.
- Emulsifiers. To keep the fatty flavor emulsion in the beverage, emulsifiers are added to soft carbonated beverages. Additionally, it prevents layer development and phase separation during beverage preservation. When shaken in aqueous solutions, saponins, chemical substances present in the roots of numerous plant species (mostly those of the genus Saponaria), form foams. Saponins in carbonated beverages form very stable foam, which is a desired quality in soft carbonated beverages.
- Antioxidant. To stop the deterioration brought on by the oxidation of flavor and color components during storage, antioxidants are added. Drinks and flavor emulsions with citrus flavors in general are more likely to oxidize. Antioxidants like butylated hydroxy anisole (BHA) and butylated hydroxytoluene (BHT) are frequently employed.

## 2. Material and methods

The author uses reference journals that have been published in 2012-2023. The journals are collected from various sources online such as Google Scholar and PubMed with the keywords dental erosion; soft drinks; dental health. The sources obtained were national journals selected based on inclusion criteria, namely journals with the type of research article or original article.

## 3. Results and discussion

Dental caries is a multifactorial illness that is influenced by a number of variables, such as salivary flow and composition, fluoride exposure, dietary sugar consumption, and oral hygiene behaviors. A typical 350-ml can of ordinary carbonated soft drink contains roughly 10 teaspoons (40 g) of these sugars; regular (non-diet) soft drinks, excluding bottled waters, contain significant levels of these sugars. Regular soft drink drinking with a high sugar content over an extended period of time may cause tooth cavities. The consumption of soft drinks and caries have been linked in numerous studies. The intake of soft drinks between meals, as opposed to during meals, is linked to the greatest risk for the development of caries in children [4, 17].

Young people that live in Northeastern Brazilian cities with tropical climates and high temperatures regularly consume citrus fruits and soft drinks, which are thought to be some of the etiological reasons for erosion, albeit these depend on other related factors. The kind and duration of exposure to an erosive agent, tooth tissue mineralization, and salivary content all have a direct impact on the prevalence of erosive lesions. According to a study done on young, physically active people, those who engage in physical activity have a higher prevalence of erosive wear due to increased consumption of citrus fruits, sports drinks, and changes in salivary flow brought on by other factors. Additionally, the erosive potential of meals and drinks is influenced by their pH as well as the frequency, intensity, and method of consumption. It is also influenced by how close intake of acidic foods and carbonated beverages is to brushing your teeth [8, 18, 19].

Dental erosion seems to have been more common over the past ten years, likely as a result of rising soft drink and fruit juice use. The high prevalence of tooth erosion in youngsters, which appears to be on the rise, is causing growing concern. Numerous studies show a connection between dental erosion and a large intake of cola-type soft drinks, other drinks with acid in them, lemon tea, and fruit juices. Due to their low pH and high titratable acidity, prolonged excessive contact of the tooth structure with acidic beverages causes proportionate loss of dental hard tissues, which results in non carious cervical tooth loss (NCTL), making it difficult for any dentist to restore these teeth. Dietary erosion can be caused by ingesting foods or beverages with a range of acidic substances. Both in vitro and in vivo investigations on frequent intake of these conveniently available beverages demonstrated enamel degradation. Most soft drinks contain phosphoric acid as one of their main ingredients. It is commonly recognized that the acid component of soft drinks like cola, which is added to give them a strange acidic flavor and a preservation quality, plays a well-established role in the erosive process [1]. The hydrogen ion concentration [H+] or acidity, as measured in pH, is primarily responsible for the immediate dissolution and softening of surface tooth structure (erosive potential) by acidic beverages made of weak acids, such as citric and phosphoric acid. The pH of extrinsic solutions (dietary beverages) coming into contact with the dentition appears to be the main determinant of dental erosion. Due to the short duration of exposure the dentition has to ingested liquids during each drinking and swallowing episode, the titratable acidity or buffer capacity, intrinsic to these acids, does not play as essential a part in dental erosion as pH.As a result, when assessing the erosive potential of beverages, pH or [H+] at the time of dental contact is a crucial chemical parameter [4, 20, 21].

Despite being the toughest tissue in the body, enamel is nevertheless a weak point when it comes to chemicals, including those in sodas and other drinks. It has been noted that the roughness is the change in the enamel that happens as an initial erosion occurrence. The roughness and hardness of the enamel surface are two reference criteria utilized to measure the damage of the acids of carbonated drinks. The enamel surfaces changed due to the soft drink industry's acidic pH. Everywhere in the world, the use of carbonated beverages and fruit juices is rising, especially among children and young people. Multiple criteria have been used to study the structural changes in the enamel, such as hardness and surface roughness. These soft drinks are dangerous because they contain acids that reduce the pH of the mouth, including citric acid, phosphoric acid, and carbonic acid [9, 22, 23, 24].

Another crucial element, namely the prolonged contact time between enamel and beverages, raises the likelihood of demineralization of the enamel. Increased sensitivity from dental erosion is followed by enamel deterioration. Another crucial element raises the likelihood. Under normal conditions, saliva tends to increase in the mouth in reaction to drinking, which promotes cleaning the tooth surface and lowers the level of acidity and, consequently, the danger of erosion. Therefore, people who have a restricted salivary flow are more likely to develop enamel erosion [9, 22].

Dental erosion happens when the enamel's fluorapatite and enamel hydroxyapatite are subjected to aqueous media with a critical pH lower than fluorapatite's pH range of 4.3 to 4.5. Mineral content and a beverage's capacity to chelate calcium from foods and beverages have a significant impact on that beverage's erosive potential. Therefore, erosion is not solely dependent on the carbonated beverage's pH, which is primarily influenced by the amount of carbonic acid present in the form of dissolved carbon dioxide. Soft drink consumption on a regular basis has been linked to dental degeneration. By altering the solubility of the enamel, the added calcium, phosphate, and fluoride in the drinks reduced

the degree of erosion. The addition of CaGP to the carbonated drinks significantly reversed both the loss of minerals and the deterioration in enamel's surface microhardness. As the CaGP concentration in carbonated beverages increased from 2 mM to 10 mM, mineral loss decreased [9, 25].

The pH and titratable acidity of the oral cavity and the soft drink both have an impact on the solubility of dental tissues. Enamel dissolves when the pH of the mouth falls below 5.5. The pH of most soft drinks, excluding bottled waters, ranges from 2.5 to 3.5, with the average pH of carbonated beverages and fruit juices being 3.44. They also include acids, primarily carbonic acid, phosphoric acid, malic acid, and citric acid, which have the potential to erode surfaces. Therefore, dental erosion is strongly linked to the consumption of soft drinks with a high acid content, both ordinary and diet/zero-calorie varieties. Not just in adults, but also in children and adolescents, dental erosion can cause severe tooth surface loss (TSL), which can lead to sensitivity in the teeth, problems with eating and drinking, and aesthetic dissatisfaction. The actual hydrogen ion availability for contact with the tooth surface is determined by the total acid level, also known as titratable acid, rather than the beverage's pH, and is regarded to be a key contributor in the development of dental erosion. The type of acid and its ability to chelate calcium, exposure time, temperature, and the amount of modifying ingredients, such as calcium, phosphate, and fluoride, in the acidic beverage are all significant determinants as well [4, 20, 21].

Although the surface enamel starts to demineralize when the pH falls below 5.5 because the external environment of the oral cavity becomes less saturated for hydroxyapatite, teeth deteriorate over a pH range of 2.0 to 4.0. Phosphoric and/or citric acid, both of which are triprotic acids that permit proton-triggered breakdown, are the main culprits behind tooth erosion brought on by beverages. By removing Ca++ in the higher pH range closer to 6, anionic citrate's chelation or ligand-promoted dissolution aids in demineralizing enamel. Only 3% of the citrate ion ionizes correctly to chelate Ca++ at an erosive pH of 3, showing that it contributes to erosiveness. At this pH, there is little process. Chelation, however, may contribute to the erosive process if anionic citrate stays in the oral cavity for prolonged periods of time and causes the pH to rise to 6. For instance, eating citrus fruits more than twice a day has been associated to dental erosion. However, the unsaturation of fluorine and hydroxyapatite that results from the high concentration of [H+] caused by the low pH of citric and/or phosphoric acid results in tooth erosion. As a result, the regulating factor for determining the erosion potential of carbonated beverages is pH [10, 26, 27, 28].

The erosive potential of a beverage can also be influenced by other elements like the quantity and saturation of calcium, fluoride, and phosphate ions in the drink. Chelating agents and buffers can also influence how easily tooth hard tissue erodes following exposure. Because cooler temperatures have an impact on the acid dissociation constant, they can also change how easily hard tooth tissue dissolves. Unrefrigerated sour beverages were more frequently linked to a higher erosion potential [29, 30].

## 4. Conclusion

Dental erosion is a growing concern, particularly due to the increased consumption of soft drinks and acidic beverages, which contribute to enamel demineralization. The acidity and pH levels of soft drinks, combined with their frequent consumption, lead to significant enamel erosion. Beverages such as carbonated soft drinks and fruit juices, which contain citric, phosphoric, and carbonic acids, lower the pH in the oral cavity, promoting enamel dissolution. The erosion process is influenced by various factors including the type of acid, exposure time, and the presence of modifying agents like calcium, phosphate, and fluoride in the drink. Studies show that the combination of high acidity and prolonged contact time between the drink and enamel leads to increased risk of dental erosion. Children and adolescents are particularly vulnerable, as they tend to consume these beverages more frequently. Furthermore, factors such as salivary flow, oral hygiene, and dietary habits play significant roles in mitigating or exacerbating dental erosion. In conclusion, reducing the consumption of acidic soft drinks and improving oral hygiene practices are essential to preventing dental erosion and maintaining dental health.

## Compliance with ethical standards

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