Effects of Fluoridated Tooth Paste on Medically Erosive Enamel in Banded Primary Teeth during Maxillary Arch Expansion in Cleft Palate Patients: An *In Vitro* Study

Research Article

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Abstract

Introduction: This study searched to validate the gravimetric method on the evaluation of enamel erosion of different pediatric liquid medicaments on deciduous molars encircled by orthodontic bands, and the effects of fluoridated toothpaste on this eroded enamel.

Method: A suitable orthodontic band was used to band each of 110 non-carious exfoliated deciduous molars, and stored in artificial saliva. These teeth were divided into: fluoridated and non-fluoridated groups (50 teeth each), and ten teeth were used as negative controls. The enamel surface of the fluoridated group was swabbed with fluoridated toothpaste for five minutes twice daily. Each group was sub divided into five clusters, of ten teeth each according to the type of medication used which included paracetamol, Adol, amoxicillin, Medazole and ViTon, according to a specific immersion cycle. The erosion induced in the enamel for all teeth was evaluated by gravimetric analysis for different intervals.

Results: The results showed that the weight loss increased with increasing exposure to liquid medication for all groups, but this increase was smaller in the fluoridated group. The highest mean weight loss after 28 hours was in ViTon, and the lowest was in Medazole [0.145 (0.005); 0.08 (0.008)] respectively.

Conclusion: Gravimetric method is a valid method for detection of the eroded enamel induced by liquid medications on banded deciduous molars, and fluoridated toothpaste significantly reduced such erosion potential.

Keywords: Gravimetric Analysis; Orthodontic Band; Deciduous Teeth; Erosion; Liquid Medications.

Introduction

Children born with a cleft palate have transverse maxillary constrictions problems [1]. Furthermore, about 8% of newborn normal children around the globe also present from this transverse maxillary narrowing [2], that is expressed by dental glossary as uni- or bi- lateral posterior cross bite. A palatal expander (PE) could be the only appropriate method to treat these transverse deficiencies [3]. Some clinicians suggest that PE use is mandatory in cleft palate children and the early correction of the transverse posterior cross bite is essential in young children [4]. This is specifically in order to relocate the follicles of the permanent teeth to a more satisfactory position, and to increase the potential for re-establishment of normal occlusal relations in the molars [4, 5].

The anchorage onto the deciduous molars seems to be the appropriate

option for early treatment. This could be due to the delay eruption of the upper first permanent molar. The deciduous second molars and the deciduous canines replacing the permanent teeth for the PE support [5]. However, the effectiveness of this modifications on the PE has been reported by some authors [6-8]. The replacing of first permanent molars has some negative side effects during orthodontic treatment [6]. So, early management using a Haas expander anchored by the deciduous molars and canines could be acceptable for transverse cross bite resolution as well as for upper anterior teeth crowding enhancement, as it has a simple design and treatment administration [6, 9]. Banding of the deciduous molars in space maintainer is also important as a prophylaxis for further orthodontic problems.

Enamel erosion has been documented as a problem affecting all age groups [10, 11]. Particularly, enamel wearing that is produced

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by diet as well as long term administration of low pH oral medication at early stage of life [12-14]. However, the active components of such oral medicaments are essential for enhancement and/or upkeep of health, at the same time, some of inactive ingredients have dangerous effects, like teeth erosion and caries [15]. Scan electron microscope and surface hardness were the only main methods used to evaluate the erosion on the tooth surface.

Since the erosive potential of sugared and acidic oral syrups that are recommended for daily application to children, especially for those wearing Hass expander or with space maintainer, the presence of the molar bands could increase the interjection possibility of retaining the medicine substrate over the deciduous molar for longer time than in normal situations. As a result, the incidence of dental erosion could be higher and the possibility of deciduous molars loss will be increased. Finally, the transverse maxillary and space loss problems would be highly complicated.

Aims

The aims of this *ex-vivo* study were to assess the validity of gravimetric method for the evaluation of the potential hard tissue erosion of different pediatric liquid medicaments induced on the deciduous molars encircled by orthodontic bands. The effects of fluoridated toothpaste on this erosive enamel, was also investigated. Correspondingly, this study determined the pH of various liquid medicaments that are recommended for daily use by pediatric physicians.

Materials and Method

The protocol of this study was approved by Research Ethics Committee of the College of Dentistry/University of Mosul; approval no. 4S/1548 in 15/08/2018.

In this research, five different kinds of oral syrups that are recommended for daily use by pediatric physicians were used. These syrups included two analgesics (Paracetamol (PA) and Adol (AD)); one antibiotic (Amoxicillin (AM)); one antifungal (Medazole (ME)) and one iron supplement (VitOn (VI)). Table 1 shows the composition and the pH of these syrups. The pH values of these selected medicines at room temperature were measured using a pH meter (Digital pH\Ion – meter, Philips, Japan).

Samples collections

A total of 110 exfoliated non-carious deciduous molars were collected from the pediatric departments of the dental center at the College of Dentistry/University of Mosul. All the teeth were hand scaled and cleaned and well examined by a dentist for structural distortion that could hinder the outcome. Each tooth was banded with a suitable orthodontic band size (Dentaurum, Ispringen, Germany). Then, these bands were cemented by Fleck's self-cure Snow White zinc phosphate cement (Keystone Industries, Singen, Germany) and all the cement accessories were removed before teeth were stored in artificial saliva at 37°C for subsequent processing.

Samples grouping

The 110 final included teeth were divided into two experimental

groups: fluoridated (FG) and non-fluoridated groups (NG) (50 teeth for each). While, remaining ten teeth were used as a negative control group. In the NG group, no material was added to the teeth surfaces. Whereas, in FG, the enamel surface of each tooth was swabbed with a thin layer of fluoridated tooth paste (Maclean training tooth paste, Glaxo Smith Kline, Brentford, U.K.) using a fine brush for 5 minutes. This procedure was performed twice daily to simulate normal oral hygiene instructions, and then re-immersed in artificial saliva. Each experimental group was subdivided into five clusters of ten teeth each. According to the five types of medication used. Then, each of these clusters were exposed to the tested medications according to a specific immersion cycle (see below). Between each immersion cycle the teeth were re-stored in artificial saliva at 37° C for 24h in separated incubators. The artificial saliva was prepared according to Taqa et al [16] and its components are listed in Table 2.

Immersion cycles

The protocol of samples immersion was derived from previously published method subscribed by Kulkarni et al. [17] in which the occlusal surface of samples were adapted to simulate the daily consumptions, using special clamp to insure the inferior surface of the crown not soaked in the medication. Each tooth was dipped for one minute in bottles containing 5 mL of the each syrup under investigation. This procedure was repeated three times per day with six hours interim between the immersion series. Then, the teeth were rinsed with deionized water and were well dried for erosive evaluation (see below). After each immersion cycle, the teeth were maintained in ten milliliter of previously prepared saliva at 37°C until subsequent immersion phase. The syrups were renewed before each immersion series [17].

Teeth erosive evaluation

The erosion of the deciduous teeth was evaluated using an updated method designated by Von Fraunhofer & Rogers [18]. This method depends on the assessment of the weight loss of the tooth after exposure to the erosive factor. So, all teeth were well dried using blotting paper at room temperature for one hour and were then weighted using a calibrated accuracy balance (Sartorius BP61S, Göttingen, Germany), the metering precision was 0.1 mg. The above procedures were repeated after 7, 14, 21, and 28 days intermissions, after the constant and regular repetition of the daily immersion series. The negative control group (ten teeth) were stored in the artificial saliva throughout the all experiment period (28 days), with regular daily refreshment of artificial saliva for all clusters, as shown in figure 1.

Composition of toothpaste

The toothpaste used in this study was composed by: Sodium mono-fluoro-phosphate (500 ppm fluoride), Sorbitol, Aqua, Hydrated silica, Glycerin, sorbitol, Titanium Dioxide, Sodium Lauryl Sulfate, Xanthan Gum, Disodium Phosphate, Aroma, Sodium Saccharin, Glycerol, Calcium Glycophosphate, Limonene CI77492, CI77491. (Maclean training tooth paste, Glaxo Smith Kline, Brentford, U.K.)

Statistical evaluations

The outcome data were put into Excel sheet. The statistical ex-

ploration was done using the statistical package for the Social Sciences software (version 19). The descriptive analysis was used to find the means and stranded deviation of weight loss for all the teeth and at different intervals. One ways ANOVA also was used to find the significant differences between the tested groups. P value was adjusted to be <0.001.

Results

The physiochemical properties and the pH of each pediatric medicinal syrups are presented in (Table 1). All the studied syrups were acidic on opening, although the pH of ME was higher than the pH of the remaining syrups (6.19). The pH of VI was lower than the pH of the remaining syrups (4.94).

Among all liquid medication, the mean of weight loss after 28 hours was the maximum in VI [0.145 SD (0.005)] while it was the least in ME [0.080 SD (0.008)]. On the other hand, NG had a higher teeth weight loss than FG under the same type of liquid medication used (Table 3).

Figure 2 shows that there was a considerable extent of weight loss of tooth in each medication, especially after 28 days. The graph also shows that the mean of total teeth weight loss was in the VI, when compared it with negative control group, the tooth weight loss was higher in VI after 7, 14, 21 and 28 days. However, other

medication also, showed higher means for the total tooth weight loss, if we compared it with negative control group. The result also showed that the weight loss increase with increasing the frequency of exposure to liquid medication for all groups.

Discussion

In this ex vivo study, the amount of erosion induced in the deciduous teeth was expressed as a weight loss. This gravimetric analysis method has been reported in the literatures and accepted internationally, as it is simple, feasible, and meaningful [19-21].

Recently, teeth erosion has been significantly documented as a main basis of tooth structure loss in children and adolescents [22]. Especially, for banded deciduous molars used in expansions of the constricted maxilla or for space maintainer purposes. As the bands as well as all the components of the expander are consider a rough irregular surfaces that could retain the medications and food remnants and increase the time of exposures of these erosive materials on the teeth enamel. However, in this study we try to simulate the oral environments by banding the teeth with orthodontic bands before exposure to medicine.

The current research indicates that the investigated syrups could possibly erode the primary tooth enamel after the previously prescribed immersion phases, which could be due to the mineral loss

Table 1. The Composition and the Mean pH of medication used in this study.

The Medication	Composition	pH
Paracetamol (PA)	Paracetamol 120mg/5Ml	5.11
Adol (AD)	Paracetamol 100mg/1ml Excipients: Propylene glycol, sorbitol, glycerol, saccharin sodium, povidone, polyethylene glycol, sodium citrate, citric acid monohydrate, FD and C red no.3, apricot and banana flavours and purified water	5.12
Amoxicillin (AM)	Amoxicillin as trihydrate usp 250 mg	5.08
Medazole (ME)	Metronidazole as benzoyl Bp 200 mg	6.19
ViTon (VI)	Akkalkara (Anaclyus pyrethrum)....15.00mg Ashwagandha (withaniasomnifera)..... 30.00mg Dalchini (Cinnamomumzeylanicum)..... 3.00mg Elaychi (Elettariacardamomum)Taj (Cinnamomum cassia).....3.00mg Nagkeshar (Mesuaferrea).....3.00mg Gohgaru (Tribuiusterrestris)Ext....5.00mg Jaylal (Myristicafragrance) ...10.00mg KauchaBeej (Mucunapruriens) Ext...5.00mg Majith (Rubia cordifolia) ...10.00mg Raisan (Pluchealanceolata) .....10.00mg Satavari (Asparagusracemosus) .....25.00mg ShilajeetShuddha (Asphaltumpanjabinum) Ext...7.50mg Amla (Phylathusembilica....5.00mg Baheda (Terminaliabelerica).....5.00mg Harde (Terminaliachebula).....5.00mg Sunth (Zingberoffcinale).....5.00mg Kali Mirch (Piper nigrum).....5.00mg Piper (Piperlongum)... 5.00mg Vidhara (Argyeiaspeciosa)Ext.....5.00mg Vidarikand (Pueraria tuberosa).....20.00mg Flavouredsugersyrup base.....Q.S. Color: Carmoisine& Sunset Yellow FCF	4.94

Table 2. Composition of artificial saliva per one liter of water: (Taqa et al., 2019).

	Component	wieght	pH
Artificial saliva	CaCl ₂	(15 mg**)	7
	MgCl ₂	(5 mg**)	
	KCl	(0.1 g*)	
	KSCN	(10 mg**)	
	Na ₂ HPO ₄	(40 mg**)	
	sodium carboxymethylcellulose	(1.0 g*)	
	methylparaben	(0.1 g*)	

*g gram **mg milligram

Table 3. Comparison of mean tooth weight loss after immersion into each medication and in four intervals of 7th, 14th, 21th and 28th days.

Type of medication	Tooth loss 7th day Mean (SD)	P*-value	Tooth loss 14th day Mean (SD)	P*-value	Tooth loss 21th day Mean (SD)	P*-value	Tooth loss 28th day Mean (SD)	P*-value
ViTon	0.025 (0.005)	0.003	0.065 (0.005)	0.0	0.105 (0.005)	0.0	0.145 (0.005)	0.0
ViTon with Fluoride	0.008 (0.0)	0.0	0.025 (0.005)	0.003	0.055 (0.005)	0.0	0.080 (0.008)	0.0
Amoxicillin	0.015 (0.0)	0.0	0.050 (0.008)	0.001	0.080 (0.008)	0.0	0.120 (0.008)	0.0
Amoxicillin with Fluoride	0.005 (0.0)	0.001	0.015 (0.0)	0.0	0.040 (0.008)	0.002	0.070 (0.008)	0.0
Paracetamol	0.010 (0.0)	0.0	0.040 (0.008)	0.002	0.070 (0.008)	0.0	0.110 (0.008)	0.0
Paracetamol with Fluoride	0.005 (0.0)	0.001	0.015 (0.0)	0.0	0.035 (0.0)	0.0	0.065 (0.0)	0.0
Adol	0.008 (0.0)	0.005	0.030 (0.0)	0.0	0.060 (0.0)	0.0	0.100 (0.0)	0.0
Adol with Fluoride	0.005 (0.0)	0.001	0.013 (0.0)	0.0	0.035 (0.0)	0.0	0.060 (0.008)	0.001
Medazole	0.008 (0.0)	0.0	0.015 (0.0)	0.0	0.050 (0.0)	0.001	0.080 (0.008)	0.0
Medazole with Fluoride	0.004 (0.0)	0.0	0.010 (0.0)	0.0	0.050 (0.00)	0.0	0.060 (0.0)	0.0
Negative Control	0.001 (0.0)	0.0	0.002 (0.0)	0.0	0.004 (0.0)	0.0	0.005 (0.0)	0.0

*P <0.001

Figure 1. Schematic the Study Design and Sample Grouping.

Figure 2. Schematic the Tooth Loss by Weight after Immersion Interval on 7th, 14th, 21th and 28thDays for Fluoridated and non-Fluoridated Groups and for all Used Medications.

caused by medicine intake. Research on primary teeth substrates are of scientific relevance, as it has been observed that there is a structural and morphological difference between deciduous and permanent teeth. The dissimilarities in the chemical conformation, rate of development and ultra-structure have been inspected between the pellicle on primary and permanent teeth. Primary enamel is more susceptible to enamel erosion with 50% more mineral loss and 30% more lesion depth. The primary enamel is less mineralized and the density of its outermost layer is lesser when compared to permanent teeth [23]. As a result, the loss of the anchor deciduous molars may lead to vital failure of the expansion in palatal constricted maxilla.

We followed previously authorized methods for erosive evaluation and immersion cycle of the oral medications used [17-19].

In the present study, the five investigated syrups have acidic components, which decreased the pH of the oral cavity and saliva as shown in table 1. However, present study showed that the pH of ME was higher than the pH of the remaining syrups (6.19). While, the pH of VI showed the lowest value among all the remaining syrups (4.94), and the pH of all the pediatric syrups used in the present study were lower than the critical pH of demineralization, as the probability of enamel erosion increases with decreasing pH [17].

During syrup production, usually the acids are added to the preparations as a buffering tool in order to preserve its chemical constancy, in addition to regulate tonicity and certify its physiological compatibility. Another reason for acid addition is to enhance flavor, and increase palatability for children [12]. However, citric acid, in spite of its weak acidity, has recently been reported to have the ability to be erosive to the enamel surfaces of the tooth, due to the chelating capability of the calcium in the hydroxyapatites [11].

Our results showed an erosive in the enamel of the banded teeth, which was expressed in this study as a weight loss, in all the tested groups on the 7th day as compared to negative control values. The VI syrups showed the maximum means of weight loss and it was statistically significant. The reason for more weight loss on the 7th day as compared to negative control group values could be due to syrups exposure. On the other hand, this difference that observed in different groups could be related to the variations in the syrups pH, as well as the used acids, the buffers added, and fi-

nally could be due to the compositions of the oral liquid medicine [24]. Supposing that the enamel for all the teeth have the same mineralization components.

On the other hand, the recent study indicated that the mean of total tooth weight loss on the 28th day was highest in VI, 0.145 (SD 0.005) and least in ME, 0.080 (SD 0.008). This may be because that ME has higher pH than remaining syrups (6.19).

The four weeks (28 days) investigated period was selected, to study the effects of long term administration of the medicine. Particularly, for young children with PE. It seems that extended treatments could be induced high tooth structure loss, and that could be greater than those marked in this investigation. However, a similar protocol was followed by Amaechi et al. [25]. Nevertheless, the oral liquid medicine investigated were nominated because they are routinely prescribed for the treatments of public childhood illnesses.

Similarly to the *in vitro* study by Scatena et al. [26] who assessed the erosive potential of pediatric liquid medicines in primary tooth enamel, the syrup immersion cycles were done for one minute three times per day, for four weeks. The tooth surface micro hardness was compared at 1, 2, 3 and 4 weeks respectively. Additionally, the scanning electron microscope was used to show tooth surface on the 28th day, which has clearly exhibited structural loss [26].

The erosive potential of liquid oral medications might be related to the regularity and interval of acid contact, it is also, related to the total volume of syrups ingested. Despite the properties of these oral syrups, the indiscriminate consumptions of children syrups, particularly by young children could increase the dental erosion and tooth loss. Even more, the administration of liquid oral syrups before bed time could worsen the condition, particularly, if it is not followed by good oral hygiene [27].

The result of current study also showed that increasing of weight loss with time were smaller in all groups used fluoridated tooth paste before exposed to medication. This may be attributed to the formation of precipitated calcium fluoride (CaF₂) that poses a reservoir of fluoride, that released fluoride ions gradually upon acid dose [28], and this also, highlights the importance of oral health care with a fluoride supplement especially for young chil-

dren with cleft palate, under fixed orthodontic therapy by palatal expander.

Therefore, the using of children's syrup necessitates concentrated oral hygiene measures with fluoridated tooth paste [29]. As well as, it is well-thought-out that the pharmacological companies should advertise the possibility of tooth erosion on drug leaflet.

Conclusion

Gravimetric method is valid for detection of the erosive enamel induced by liquid medications on banded deciduous molars, and the Fluoridated toothpaste has a significant reduction of such erosion potential. Majority of children syrups were unaware concerning the sweetening agents and acidity, which cause aggressive effects on the teeth enamel. Also, high care should be considered after prescribing liquid medicaments, especially for young children with constricted maxilla and under fixed orthodontic treatment. Hence, brushing with fluoridated tooth paste should be delivered to enhance the oral health related to the quality of life in such children.

Limitations of the Study

The limitations of this *ex vivo* study include: the teeth were immersed for 1 minute in each medication. Usually, without effect of complaint which occur under normal oral conditions during *in vivo* study. Also, in order to better imitate to clinical conditions, we used pH-cycling model. However, *in vitro* study might not reproduce the results of an *in-vivo* one. Besides, the effect of oral factors such as, saliva and dental plaque on the enamel remineralization and mineral loss from tooth surface could not be considered.

Clinical implication of the study

This study shows the importance of oral hygiene instructions for young children. Especially, for those having Hass expander or even with space maintainer, as the deciduous teeth are encircled with molar bands. The use of fluoridated tooth paste before oral consumption of liquid medicine are highly reduce the erosive potential of the deciduous teeth and increase the survival time of them.

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