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COMPARATIVE EVALUATION OF REMINERALISATION POTENTIAL, SURFACE STRUCTURE AND ADHESION BETWEEN GLASS IONOMER AND CALCIUM HYDROXIDE IN PRIMARY TEETH – AN IN VIVO STUDY

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ABSTRACT

The objective of the clinical study is to compare the remineralisation potential of Fuji IX with Dycal at different time intervals. 55 children in the age group of 9-13 years were selected with class I caries lesions in primary molars. Teeth with no obvious clinical signs and symptoms and a minimum dentine thickness of 0.5 to 1mm and no radiographic changes were selected. Teeth were divided into three groups – control and two experimental groups. The mineral content analysis was done with the help of EDAX. The minerals analysed were Sodium, Magnesium, Aluminium, Silica, Phosphorus, Chlorine , Calcium. Teeth in the control group showed lowest mineral content. In the experimental group Fuji IX demonstrated better remineralization potential than Dycal.

KEY WORDS: **Remineralisation, Glass Ionomer, Calcium Hydroxide, Mineral Content Analysis**

INTRODUCTION

Ever since dental researchers understood the reversibility of dental caries in its initial stages, most of the research was directed towards enriching the mineral content of the tooth. One of the means of achieving this was with the use of fluorides. However, during the same period the healing properties of calcium hydroxide in the deep carious lesions was observed.

Treatment of deep carious lesions with different restorative materials has been shown to cause remineralisation of the carious dentine.[1] It has been found that a deep lesion remineralises to a greater degree than a shallow one. The correlation between initial demineralisation and more rapid remineralisation was attributed to the faster diffusion of ions into the more porous extensive lesions. It is doubtful whether complete remineralisation takes place in situ. It maybe the crystal growth in the surface zone that blocks the further remineralisation of the deeper layers. However, when the lesion is effectively arrested or inactivated, the clinical benefits of partial or complete remineralisation are achieved. The duration of remineralisation studies usually vary from 14-80 days [2].The term remineralisation thus refers to a dynamic process, not an end product. Short term studies which in effect measure the initial rate of remineralisation are therefore justified. The concept of remineralisation should not be restricted to the process of recalcification, rather it should include attempts to replace the lost calcium and phosphorus with other minerals by chemical processes of exchange, substitution, physical and chemical bonding [3].

The dental filling materials that have promising qualities are the glass ionomer cements. The two key features of this group of materials are their ability to bond chemically to the tooth structure and their fluoride releasing properties. There is also evidence both in vitro and vivo that glass ionomers not only prevent new caries formation but also facilitate remineralisation of the existing lesions. The anticariogenic properties of Glass Ionomer cement have been demonstrated [4]. Fluoride release and antibacterial effect decreased with time and remained measureable even after 60 days[5]. The potential for remineralisation has been attributed to the release of the fluoride ions which are incorporated into the glass powder during the manufacturing process. Some of this fluoride leaches into the cement matrix during the setting reaction and is available for the tooth. Fluoride acts as a catalyst for the uptake of calcium and phosphate ions. Despite their potential cariostatic effects, glass ionomers have not been used extensively as restorative materials largely due to their poor physical properties. Attempts to improve these properties involved the use of larger particle size, greater powder to liquid ratio. One such restorative glass ionomer that has been introduced is the Fuji IX mainly for the atraumatic restorative technique with their new improved physical properties. The use of this restorative material has been advocated as it has the advantages of minimal instrumentation where the deep caries is excavated and once the infected dentine is removed, the tooth is restored.

Sowden [1] has shown that conventional pulp capping material like calcium hydroxide can remineralise the demineralised dentine. Chemical, radiographic and histologic studies were done later which showed remineralisation of the carious dentine when calcium hydroxide was used as a base. Calcium Hydroxide is classified as a strong base and lower the viscosity higher will be the ionic dissociation. Its antibacterial effect was evaluated by Estrella et al(1995) [4]and Siqueira and Uzeda (1997)[6]. Eidelman et al [7] determined the effect of a preparation of calcium hydroxide on the carious dentine and a highly significant increase in the phosphorus content was noted in the treated tooth compared to the untreated sample of the carious dentine. Once the carious process is arrested, it may be possible for the carious dentine to recover the lost mineral in some way. The integrity of the dentinal tubules maybe indispensible for the exchange of the minerals from the pulp to the dental tissues. Evidence presented by histologic studies has shown that the tubules in the calcium hydroxide treated carious dentine reconstructed to some degree. There is good evidence that remineralisation takes place and this could progress to a point where it approaches the mineral content of the sound dentine.

Materials and Methods

This study was conducted in the Department of Pedodontics and Preventive Dentistry, College of Dental Surgery, Manipal, in collaboration with the Department of Metallurgy, Indian Institute of Science, Bangalore.

Fifty five children in the age group of 9-13 years were selected for the study who were undergoing treatment in the dept. of Pedodontics. The criteria for selection included:

1. Children with decayed primary molars.
2. Class I deep carious lesions with no obvious clinical signs and symptoms with a minimum dentine thickness of 0.5-1mm.
3. No radiographic changes appreciable in the furcation and periradicular area.
4. Over retained teeth.
5. Informed consent from the parent regarding extraction at a later date. Ethical committee clearance was obtained.

The subjects were divided into three groups
Control group : Five teeth from the subjects fulfilling the above criteria.

Experimental groups : Fifty teeth divided into

Group I : 25 teeth restored with Fuji IX restorative material.
Group II: 25 teeth restored with Dycal.

Group I and II consisting of 25 teeth in each sub divided into five groups depending on time interval :

Group I - Subgroups

Sub group 1 – Teeth restored with Fuji IX for 2 weeks – 5
Sub group 2 – Teeth restored with Fuji IX for 4 weeks - 5
Sub group 3 - Teeth restored with Fuji IX for 6 weeks – 5
Sub group 4 - Teeth restored with Fuji IX for 8 weeks – 5
Sub group 5 - Teeth restored with Fuji IX for 10 weeks - 5

Group II - Subgroups

Sub group 1 – Teeth restored with Dycal for 2 weeks – 5
Sub group 2 – Teeth restored with Dycal for 4 weeks - 5
Sub group 3 - Teeth restored with Dycal for 6 weeks – 5
Sub group 4 - Teeth restored with Dycal for 8 weeks – 5
Sub group 5 - Teeth restored with Dycal for 10 weeks – 5

Conventional Class I cavities were prepared, the outline form mainly depending on the extent of the caries. The cavity depth was maintained at 0.5 to 1mm from the pulpo-dentinal junction. The control group were first given a base of pink wax of about 1.5 to 2 mm thickness. The wax was inserted into the cavity without softening followed by restoration with amalgam. The teeth were extracted after 2 weeks.

The teeth in group I were restored in the following manner. The powder liquid ratio was maintained at 2.7 : 1. The working time was around 2 minutes and the setting time was 2 minutes 20 seconds. The mix was packed incrementally into the cavities.

The teeth in Group II were restored in the following manner. The Base and Catalyst were taken on the mixing pad of equal lengths and then mixed. The mix was immediately placed in the prepared cavity and condensed. A minimum thickness of 1.5 mm was maintained. Temporary restoration was done with IRM, reinforced Zinc Oxide restorative material. Appointments were given at subsequent time intervals for extraction at a later date. The children were instructed to inform in case of any pain or discomfort was noticed. The teeth were then extracted under local anesthesia.

Specimen preparation

The samples for EDAX analysis were done in the following manner. The teeth were cleaned with hand scalers and stored in distilled water till sections were made. The roots were separated and then sectioned longitudinally using Horocco diamond disc with intermittent water spray. The cut specimens were made in 2x2mm in diameter. They were allowed to thoroughly dessicate for 48 hrs before gold coating. The samples need to be coated by an electron conducting material to make them conductive with the help of an ion sputtering device. The minerals analysed in the present study were sodium, magnesium, aluminium, silicon, phosphorus, chlorine, calcium and zinc using EDAX.

The mineral analysis was done at two different sites

1. At the tooth restoration interface in the dentine
2. At 200 micro meters from the interface.

All the obtained results were computed and subjected to statistical analysis with Student t test using SPSS package. The data was analysed with two groups as well as between the groups.

Results

The intergroup comparison between the Control Group and the experimental Group I at 10 weeks showed significantly high values of sodium and zinc in the control group whereas group I (FUJI IX) showed high values of aluminium, phosphorus and calcium.

At a distance of 200 µm in the dentine from the interface demonstrated a statistically significant higher silica content in the control group. A highly significant phosphorus content with a mean of 38.02 ±3.9 and a P value of 0.002 in the Fuji IX group was observed.

Comparative evaluation between the control group and the experimental group II at 10 weeks showed a statistically significant high value of Sodium and Zinc in the control group whereas the Dycal group showed significantly high values of aluminium and calcium. The intergroup comparison at 200µm showed high value of silica and zinc whereas Dycal group showed significantly high phosphorus content.

Comparative evaluation between the two experimental groups at 10 weeks demonstrated significantly high values of aluminium, silica, phosphorus and calcium in the Fuji IX group whereas the Dycal group showed high values of sodium, magnesium and zinc (Table 1). At 200 µm in the dentine high values of sodium and zinc were seen in the Dycal group.

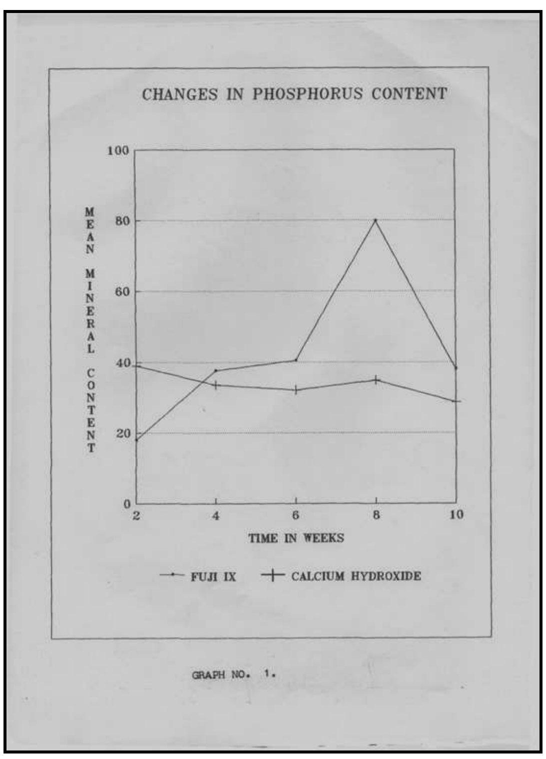
The results of the present study can be summarized as follows:

1. The control group demonstrated significantly low mineral content as compared to the two experimental groups.

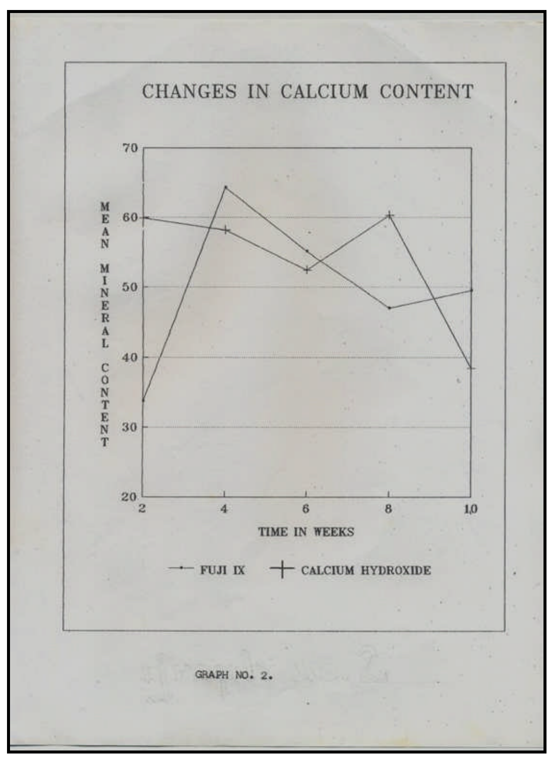
2. Intergroup comparison between the two experimental groups demonstrated significant increase in the mineral content in Fuji IX group as compared to Dycal group as shown in Graph 1, 2.

Table 1
INTER GROUP COMPARISON BETWEEN FUJI IX AND CALCIUM HYDROXIDE TEN WEEKS

	FUJI IX MEAN ± S.D	CA(OH) MEAN + S.D	P Value
Na	2. 17 ± 0.50	2.91 ± 0.47	.046*
Mg	1 . 1 5 ± 0.63	2.12 ± 0.48	.028*
Al	8.38 ± 0.33	-0.63 ± 0.35	.000***
Si	1 .61 ± 0.76	0.42 ± 0.20	.023*
p	38.02 ± 3.98	28.63 ± 3.03	.004**
Cl	0.46 ± 0.64	0.24 ± O. 16	.505
Ca	49.50 ± 5.10	38.41 ± 7.07	.024*
Zn	5.34 ± 1 . 18	31 .55 ± 2.30	.000***
P values :* < 0.05, ** < 0.001 ,*** < 0.0001			



Graph 1



Graph 2

Discussion

Calcium and phosphorus are the main constituents of the mineral phase of dentine [8]. Hence in the present study these mineral changes were considered as the main criteria for the assessment of mineralized dentine. If the rate of the transport of the mineral into the lesion is constant, then the proportional gain in the mineral content over a given time should be lesser for a deep lesion than a shallow one[9]. However the correlation between the initial demineralization and a more rapid remineralisation was attributed to the faster diffusion of ions into more porous extensive lesions. The present study is done over a time period of 70 days as the duration of remineralization reported in most of the studies was 14 to 80 days[2].

Eidelman et al[7] stated that once the carious process is arrested, it is possible for the dentine to recover the lost mineral. Though there is good evidence to substantiate that remineralization does take place, the mechanism remains obscure. Electron probe micro analysis has been used for semi-quantitative analysis of the mineral elements in tooth tissues since 1966. This method allows for identification and quantification of elements present in both very small and large percentages in tissue. From the present study it can be observed that the mineral content of the remineralized dentine at the end of 10 weeks is similar to that of the normal dentine values as reported by Tjaderhane et al [10]. The present study included all the minerals along with Al, Si, Cl. One of the chief limitations of the present study was the inability of energy dispersive x-ray analyser used in the present study to detect the elements with atomic number less than 11, lighter elements detected. Fluoride which is the chief ingredient involved in the remineralisation process could not be analysed.

In the present study, the lower mineral content in the control group than the experimental groups can be attributed to the loss of minerals during the demineralisation which continues to take place till the lesion is arrested or a suitable restorative material is placed. Thus the phosphorus and calcium content in the experimental group I demonstrated a higher content than the other groups.

The control group demonstrated significantly high values of Zinc similar to the observations of Tjaderhane, Hietala and Larmas[10] who found a reduction in the mineral content of Ca, P, Na, Mg and total content of elements as well as increase of Zn in the carious lesions. They were in accordance with previous findings of X-ray microanalysis done by Hals et al [11]. The high amount of zinc in the carious dentine might be an indication of its role in the tissue degradation. Zinc is an essential activator for matrix metalloproteinases, which are required for the cleavage of collagen and this could be the reason for the changes in the zinc content at different time intervals.

The presence of low content of magnesium in the demineralised dentine is believed to be due to loss during the earliest stages of carious demineralisation. The high content of magnesium in dentine under carious lesions seen in interproximal groups probably reflects the precipitation of Mg as whitlockite.

In the present study the mineral content values at different time periods in both the experimental groups definitely indicated that hypermineralisation took place with the mineral content values higher than the normal dentine values reported in the study conducted by Tjaderhane et al [10]. At the end of the 10 weeks, the mineral analysis revealed values closer to the normal dentine structure indication that though initially carious lesion is hypermineralised, there is a definite loss of mineral content to bring it to the original level. The normal dentinal values were noted from the study done by Tjaderhane [10].

The inter group comparison between the experimental groups over a time period of ten weeks in the phosphorus content are shown in Graph No.1. In group I there was a gradual increase in the phosphorus content from the two week time period till eight weeks followed by a decrease at ten weeks. This decrease could be due to the initial hypermineralisation followed by changes in the mineral content approaching the normal dentine values. Calcium hydroxide group demonstrated higher levels of phosphorus at two weeks followed by a decrease with time and not reaching the values comparable to the normal(Table No. 1). This clearly indicates that the mineralisation potential of Group I is better than Group II over a time period.

There was no single explanation for the increase in the phosphorus content found in the treated samples but there was evidence to support the fact that teeth were subjected to a measurable amount of phosphate metabolism indicating the process of mineralisation. In Group I a significant increase in the phosphorus content than Group II at the interface over a period of ten weeks could be considered as an index of the degree of mineralisation initiated in the experimental dentine.

The intergroup comparison between the two experimental groups over a period of ten weeks in the Calcium content are shown in Graph No.2. Group I demonstrated a significant increase in the calcium content from two week period to the four week period after which a gradual decrease was found at the interface. At the end of ten weeks the calcium content of the Group I was higher than the normal dentine values. Therefore, the findings of the present study show that even though glass ionomer cements do not have calcium content as present in calcium hydroxide, they have the potential to initiate uptake of calcium which might have its origin in the dentine or the pulp.

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