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Combined efficacy of topical iodine and fluoride varnish as against fluoride varnish alone in preventing dental caries in children- A comparative study

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Abstract

Aim: To evaluate the combined effect of 10% povidone iodine and 5% fluoride varnish as against 5% fluoride varnish alone in preventing dental caries in moderate to high caries risk children.

Method: 200 Children of age 4-7 years having decay in their primary molars were selected from government primary schools of Sangareddy. The sample was divided into experimental and control group of 100 each. Experimental group received topical application of both 10% Povidone iodine and fluoride varnish while Control group received only fluoride varnish. Topical application was done in both groups for every 3 month interval for a period of 1 year. Caries recording was done at baseline, 6 months and 12 months. New carious lesions (decayed teeth dt) in primary dentition were recorded by using **modified World Health Organization(1968) index** and progression of the existing carious lesions was recorded by **GJ Mount Site & Size classification**

Results: Experimental group showed significant reduction in mean decayed teeth when compared to control group at both 6 month and 12 month interval period. (p value<0.001; Sig) (Table 3, Chart 3). Incremental of dental caries is less in Experimental group when compared to control group at both 6 month and 12 month interval period with a significant value (p value <0.001; Sig). (Table 4) (Chart 4).

Conclusion: Combined topical treatment with 10% povidine iodine along with 5% sodium fluoride varnish is more effective than treatment with varnish alone in preventing dental caries in children.

Keywords: Povidine Iodine, Fluoride Varnish, Prevention of Dental Caries.

Introduction

Oral cavity is the mirror of general body and so is the oral health an integral part of general health. With increasing life expectancy of the Indian population, oral health is bound to play a major role in improving quality of life. In India, dental problems are consistently increasing both in prevalence and severity over the last five decades. This can be attributed to shift in diet pattern towards more refined food (fast food) and poor oral hygiene. Although

these diseases may not be life threatening, yet their treatment modalities are highly expensive. In addition they can be easily prevented and controlled to a large extent by public education, motivation and various preventive modalities like fluoride therapies and antimicrobial agents.[1,2]

Dental caries is a microbial disease that continues to pose a worldwide health problem. In young children Dental caries has a multifactorial etiology. Maternal factors such as high Distal Mesial FacialScore (DMFS), low education level, prolonged breast feeding and pacifier use are the risk factors for the colonization of caries related microorganisms. Besides low socioeconomic status, poor oral hygiene (presence of visible dental plaque), lack of fluoride exposure and an abnormal saliva secretion rate also contribute to its etiology. Its prevalence increases with age and the number of erupted teeth.

Caries control may benefit the persons with high streptococcus mutans levels who are considered to be at high risk for dental caries. This represents an important economic aspect as targeting the appropriate risk group and implementing the preventive dental care for them can lower the cost for further dental treatment.

A number of preventive programs focusing primarily on encouraging the twice daily use of fluoride toothpaste at an early age have been implemented and assessment of its effectiveness in reducing caries in high risk children.[2] Various antimicrobials have been used in oral cavity with varying efficacy. These chemical antimicrobial substances are capable of inhibiting bacterial adhesion, colonization and metabolic activity ultimately affecting the bacterial growth.

Community water fluoridation reduces dental caries[5] but the practicality is a big question in developing countries like India there is no centralized water supply system, which makes the initial cost of implementation very high. However, besides water fluoridation, caries prevention programs can be effectively carried out through topically applied fluorides like varnishes. [6]

The varnishes adhere to the tooth surfaces for longer period and prevent the immediate loss of fluoride after application, thus acting as slow reservoir of flouride.[6]

C.G. Emilson states that though fluoride is one of the most successful agent in caries prevention but it has limited antimicrobial activity and the other drawback is that it is not advisable in patients with fluorosis and patients with kidney disorders. [7]

The current standard Preventive measures usually involve a combination of dietary counselling, oral hygiene instructions and fluoride application. But none of these interventions specifically targets *Streptococcus mutans*, the chief pathogen responsible for caries. Furthermore, children who have had “one-time” restorative treatment often quickly develop new caries following treatment.[10-12]

Therefore, current methods of caries management that are limited to traditional preventive approaches in combination with restorative treatments have proved inadequate to control the disease.[10-15] New methods of managing dental decay in the primary dentition need to be developed.

An antibacterial agent that is effective and also acceptable to young children will be a useful supplement to current techniques for the prevention of caries. Iodine has long been known as an antibacterial agent.[16]

With increasing number of different agents for preventive treatment of the teeth, it is very important to evaluate the effect of these agents on microflora and/or on caries activity and ultimately choose the one with maximum antibacterial effect, one which is acceptable by the

individual, cost effective and has less or no adverse effects.

The in vitro and in vivo iodine antiseptic literature on dental caries from 3 decades ago was promising but most human studies were very small[17, 18]. There has been a recent series of pilot and small-scale clinical studies examining the efficacy of PVP-I in young children some with established active early childhood caries with strongly encouraging data [16, 18-21]. Combining fluorides with antimicrobials may be of value because fluorides alone do not provide complete protection[22-23].

This study is designed with a notion that, povidone iodine is a potent antimicrobial agent against streptococcus mutans and sodium fluoride varnish has both antimicrobial activity and remineralisation potential. Thus the combined use of these agents may prove beneficial for reducing the streptococcus mutans in oral cavity and in turn help in prevention of dental caries.

The purpose of this study is to compare the effectiveness of combined treatment with PVP-I followed by fluoride varnish versus treatment with fluoride varnish alone. The hypothesis tested was that combination treatment was more effective in preventing new decayed teeth than fluoride varnish alone in children.

Aims & objectives of the study

1.To evaluate the combined effect of 10% povidone iodine and 5% fluoride varnish as topical anticaries agent in moderate to high caries risk children.

2.To evaluate the progression of already existing caries in children

3.To evaluate new carious lesions developed during the follow up period.

Patients and methods

Children aged 4-7 years having decay in their primary molars were selected from government primary schools of Sangareddy.

Sample Size A total 200 subjects were selected for the study. The sample was divided into experimental and control group of 100 each. Experimental group received topical application of both 10% Povidone iodine and fluoride varnish while Control group received only fluoride varnish for every 3 month interval for a period of 1 year.

Inclusion criteria

1. Children having primary teeth / early mixed dentition stage
2. Age range between 4 to 7 years
3. At least 2 cavities should be present on the deciduous molars.
4. Carious teeth but no definitive pulpal involvement on clinical assessment

Exclusion criteria

1. systemic diseases or periodontal diseases
2. children under long term medications that might affect oral flora or salivary flow
3. Patients having more than 6 cavities.
4. Patients with special health care needs.

Materials used :Mouth mirror, probe , tweezer,cotton,Sterile cotton swab,Applicator brush,Chip blower.10% PVP Iodine and 2% sodium fluoride varnish.

Methodology

Children who fulfilled the inclusion criteria were identified during initial examination and recorded. All the children in both the groups received oral hygiene instructions a tooth brush and fluorinated tooth paste to be used at home. After giving oral hygiene instructions number of decayed teeth (dt) was recorded as per the **modified WHO (1968)**[58] index and progression of the existing carious lesions was recorded by **GJ Mount**

(2009) Site & Size classification[59]. After brushing session is over, the topical application was done.

Experimental group

Experimental group received 0.2ml of 10% PVP-iodine (1 percent active iodine, microshield, PVP-S, Johnson &Johnson, India) approved by the Food and Drug Administration (FDA) for topical use in the mouth**.** The teeth were dried with chip blower and isolated with cotton rolls. A 0.2 ml solution of 10% Povidone Iodine (containing 1% active iodine) was applied for 4-5 minutes using a small sterile cotton swab. After application, the excess was removed with the gauze piece, then dried again and coated with fluoride varnish at the same visit.[16 39 49 50 54] A total of 0.20 ml of iodine solution was used for each treatment- a dose that contains 2 mg of iodine, which is nontoxic when applied.[60] The children were instructed not to swallow and eat or brush his or her teeth for 1 hour. The treated individuals received a total of four combined applications of 10% povidone iodine and fluoride varnish at interval of 3 months during the study period.

Control group

Control group received 0.2ml of fluoride Varnish (Fluoritop SR, ICPA health products Ltd. Mumbai, India) as it is easily available and cost effective. It contains 50 mg sodium fluoride per ml equivalent to 22.6 mg of fluoride in slow release form. The teeth were dried with chip blower, wiped with cotton gauze and but not isolated with cotton rolls as varnish being sticky has a tendency to stick to the cotton. The application is done first in mandibular arch as saliva collects more rapidly around mandibular arch followed by maxillary arch with the help of a single tufted brush[61]. After application the patient is made to sit with mouth open for four minutes before spitting. The children were instructed not to eat or brush his or her teeth for 1 hour. Caries recording was done at baseline, 6 months and 12 months. New carious lesions (decayed teeth dt) in primary dentition were recorded by using **modified WHO (1968) index**[58] and progression of the existing carious lesions was recorded by **GJ Mount Site & Size classification(2009)**[59]

Results

A total sample of 200 children was randomly selected from the government schools of Sangareddy. The sample was divided into 100 patients in Experimental group and 100 in control group. Experimental group received 0.2 ml of 10% povidone iodine followed by 0.2ml of fluoride varnish while control group received 0.2 ml of fluoride varnish alone for every 3 months up to 12 months. Caries recording was done at baseline, 6 months and 12 months. New carious lesions were (decayed teeth dt) recorded by using **modified WHO (1968)**[36] index and progression of the existing carious lesions was recorded by **GJ Mount Site & Size classification.**[35] At the end of the study 12 children in experimental group and 8 children in control group lost the follow up. While recording the carious primary teeth in patients few of them had decay in permanent teeth also but those scores were for descriptive purpose only not for statistical analysis.

Statistical data

Statistical analysis: All the analysis was done using SPSS version 14. A p-value of <0.05 was considered statistically significant. Comparison of mean values of decayed teeth from baseline through 12 months was done using repeated measures ANOVA with post-hoc Bonferroni test. Comparison of difference of scores from baseline with follow-ups (6 and 12 months) was done using independent sample t test. Comparison of proportion of individuals with increment or decrement caries scores was done by chi-square test.

Age

The mean age in experimental group (n=88) is 5.59(SD 1.09) and the control group (n=92) mean age is 5.36(SD 1.01) (Table 1, Chart 1)

Gender

When gender was taken into account, the Males accounted for 49% in Experimental group & 58% in Control group respectively and females accounted for 51% in Experimental group and 42% in control group respectively (Table 2, Chart 2).

Mean decayed teeth in primary teeth

Mean decayed teeth in Experimental group (N= 88) is 3.47, 3.98, 4.57 at baseline, 6months and 12 months respectively.

Mean decayed teeth in Control group (N= 92) 3.2, 4.24, 5.14 at baseline, 6months and 12 months respectively.

At 6 months follow-up, compared to control group the Experimental group has less mean decay tooth (d t) score which has statistically significant p value(<0.001; Sig) (Table 3, Chart 3).

At 12 months follow-up ,Compared to Control group the Experimental group has less mean decay tooth (d t) score with statistically significant p value(<0.001; Sig) (Table 3, Chart 3).

Increment of dental caries in primary teeth

At 6 months follow-up, the Mean Increment of dental caries is by 0.51(SD 0.63) in Experimental group (N= 88) while it is 0.99(SD 0.65) in Control group (N=92) (p <0.001; Sig value). (Table 4) (Chart 4)

At 12 months follow-up, the Mean Increment of dental caries is by 1.10 (SD 0.90) in Experimental group (N= 88) while it is 1.89 (SD 0.87) in Control group (N=92) (p <0.001; Sig value). (Table 4) (Chart 4)

Proportion of patients with progression of decay in primary dentition

At 6 months, Proportion of patients with increase in size of the decay is 46.6% in Experimental group and 78.3% in Control group. (Table 5) (Chart 5 a)

In 52.3% of Experimental group & 21.7% of the control group showed a same size of the decay and size of the carious lesion is decreased in 1.1% of experimental group in and none in control group when compared to baseline.(Table 5) (Chart 5 a)

At 12 months, Proportion of patients with increase in size of the decay is 75% of in Experimental group and 92.4% of patients in Control group. (Table 5) (Chart 5 b)

In 23.9% of Experimental group & 7.6% of the control group showed a same size of the decay and size of the carious lesion is decreased in 1.1% of experimental group in and none in control group when compared to baseline. (Table 5) (Chart 5 b)

Grades of dental caries in primary dentition

The grades of dental caries in primary dentition are recorded using GJ MOUNT site and size classification. **(Table 6)**

The total number of size 0 lesions in experimental is 28 while it is 37 in control group and size 1 lesions are 607 in experimental and 578 in control group. Size 2, size 3 and size 4 lesions are 350, 73, and 34 in experimental group & 457, 143, 27 in control group respectively. **(Table 7)**

Mean decayed teeth in permanent teeth

The mean decayed teeth (DT) in experimental group are 0.61, 0.94, 1.28 at baseline 6 months & 12 months respectively. (Table 8)

The mean decayed teeth (DT) in control group are 0.47, 0.53, 1.20 at baseline 6 months & 12 months respectively. (Table 8)

These values are only for descriptive purpose but not for the statistical analysis.

Figure 1: Simple bar diagram to show the mean age in experimental and control group

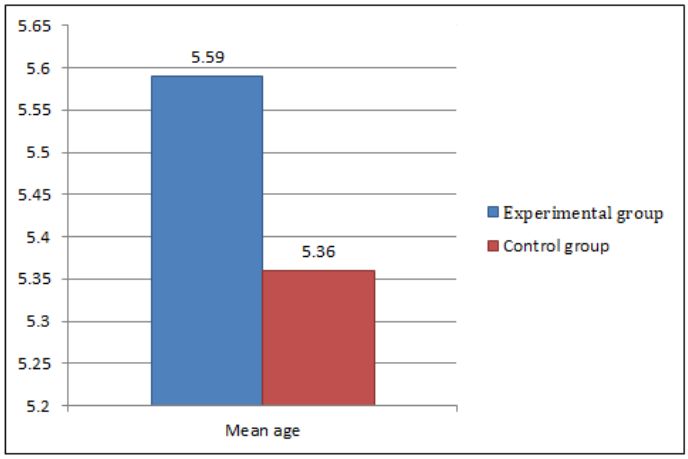

Figure 2: Simple bar diagram to show the sex distribution in experimental and control group

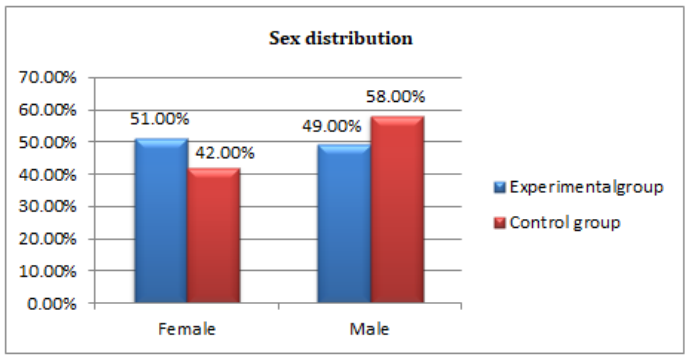

Figure 3: Simple bar diagram to show mean decayed teeth (d t) in Primary teeth

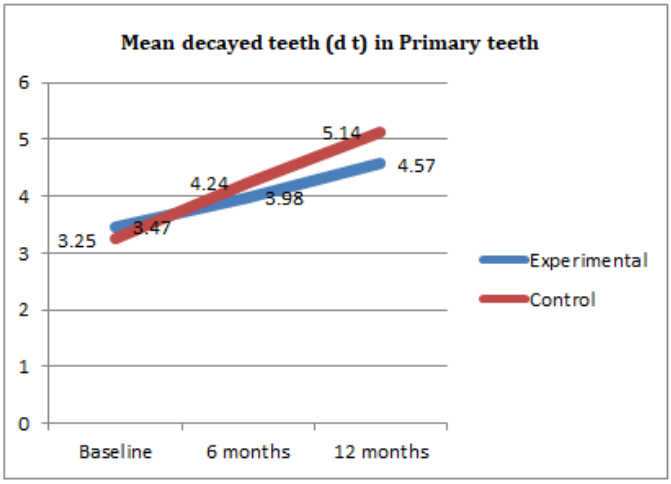

Figure 4: Simple bar diagram to show increment of dental caries in primary teeth

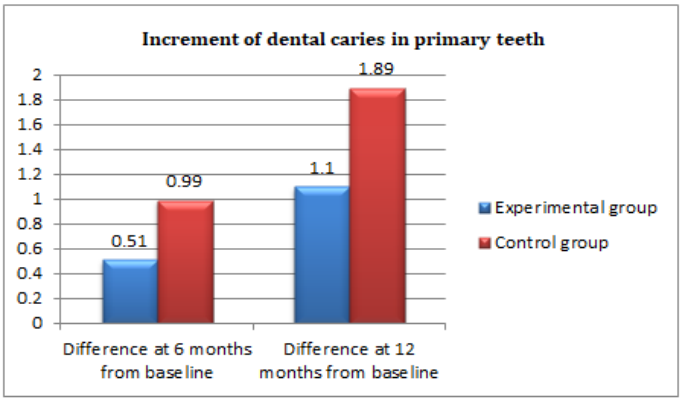

Figure 5 a: Simple bar diagram to show Proportion of patients with progression of decay in primary dentition at 6 months.

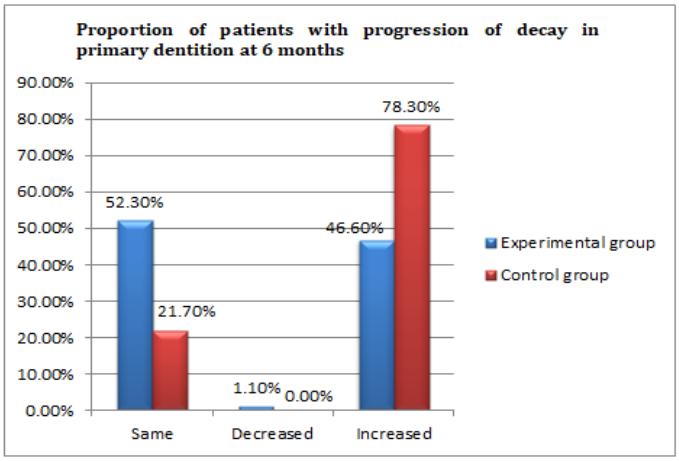

Figure 5 b: Simple bar diagram to show Proportion of patients with progression of decay in primary dentition at 12 months.

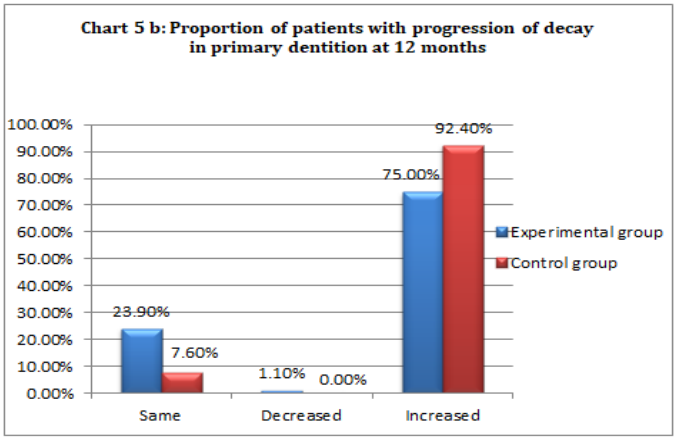

Figure 6 : The caries balance [22]

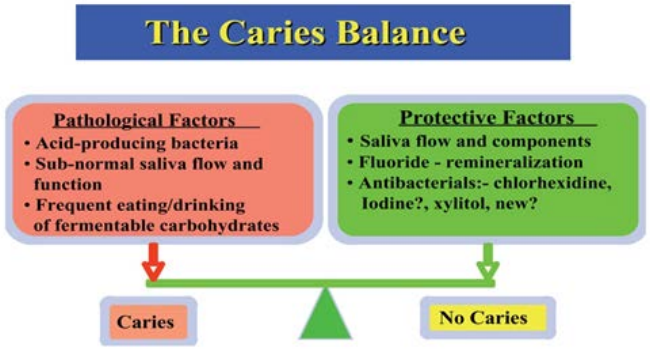

Figure 7 : PVP-I structure [91]

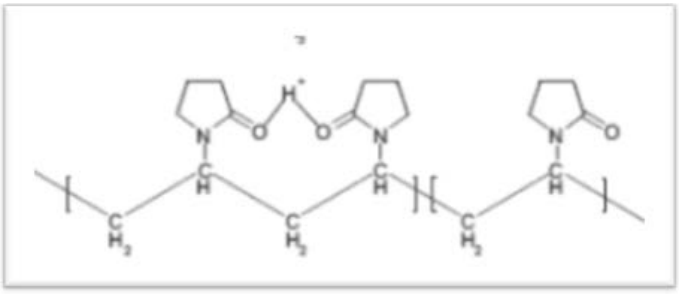

Table 1: Mean age in experimental and control group

Group	Experimental(n=88)		Control group(n=92)	
	Mean	SD	Mean	SD
Mean age	5.59	1.09	5.36	1.01

Table 2: Sex distribution in experimental and control group

Sex	Group			
	Experimental		Control	
	N	%	N	%
Female	51	51.0%	42	42.0%
Male	49	49.0%	58	58.0%

Table 3: Mean decayed teeth (d t) in Primary teeth

Dentition	group		Mean	SD	N	p-value	Post-hoc test
Primary	Experimental	Baseline	3.47	1.347	88	<0.001; Sig	B<6<12
		6 months	3.98	1.561	88		
		12 months	4.57	1.786	88		
	Control	Baseline	3.25	0.657	92	<0.001; Sig	B<6<12
		6 months	4.24	0.965	92		
		12 months	5.14	1.135	92		

Table 4: Increment of dental caries in primary teeth

Dentition	Increment	Group	N	Mean	SD	p-value
Primary	Difference at 6 months from baseline	Experimental	88	0.51	0.63	<0.001; Sig
		Control	92	0.99	0.65	
	Difference at 12 months from baseline	Experimental	88	1.10	0.90	<0.001; Sig
		Control	92	1.89	0.87	

Table 5: Proportion of patients with progression of decay in primary dentition

Dentition			Group				p-value
			Experimental		Control		
			No of patients	%	No of patients	%	
Primary teeth	6 months	Same	46	52.3%	20	21.7%	<0.001; Sig
		Decreased	1	1.1%	0	.0%	
		Increased	41	46.6%	72	78.3%	
	12 months	Same	21	23.9%	7	7.6%	0.006; Sig
		Decreased	1	1.1%	0	.0%	
		Increased	66	75.0%	85	92.4%	

Table 6: Grades of dental caries in primary dentition

	GJ MOUNT classification	Experimental	Control
Baseline	Size 0	10	14
	Size 1	216	208
	Size 2	75	100
	Size 3	8	17
	Size 4	7	0
6 Months	Size 0	11	9
	Size 1	213	190
	Size 2	112	154
	Size 3	13	39
	Size 4	10	2
12 Months	Size 0	7	14
	Size 1	178	180
	Size 2	163	203
	Size 3	52	87
	Size 4	17	25

Table 7: Decayed teeth (D T) in Permanent teeth(Not for statistical analysis)

Dentition	Group		Mean	SD
Permanent	Experimental	Baseline	0.61	1.037
		6 months	0.94	0.938
		12 months	1.28	0.752
	Control	Baseline	0.47	0.516
		6 months	0.53	0.516
		12 months	1.20	0.414

Discussion

Good oral health is an integral component of good general health. Many children have inadequate oral and general health because of active and uncontrolled dental caries. According to United States Surgeon General's report on oral health, dental caries is the single most common chronic childhood disease[44]. In recent years, a steady increase of the prevalence of dental caries in developing countries has been observed and in a developing country such as India with a population of 1.25 billion the problem seems even more challenging. Increased urbanization and changes in food customs are contributing factors in dental health in these countries.[63]

Prevention of dental caries and minimal intervention dentistry plays a vital role in pediatric dental practice. In the present centaury, great emphasis is placed on caries risk assessment, early diagnosis and caries control. Thus, the focus has been shifted to preventive strategies and minimal intervention to eliminate the most prevalent disease 'dental caries'[1] which is a multifactorial disease that will not occur without the presence of the microorganisms; streptococcus mutans playing a major role. [64 65]

The current community standard of care for treatment of high risk caries patients is usually restricted to removal and restoration of carious teeth, application of topical fluoride, counselling regarding decay-promoting feeding behaviours and oral hygiene instructions[8] but none of these interventions specifically targets *Streptococcus mutans*, the chief pathogen responsible for caries [66]. Thus, treating a carious tooth in children with high caries experience by providing a restoration does not cure the disease. If the unfavourable oral environment that caused the cavity persists so will the disease and more restorations will be required in future.[44]

Approximately 40 % of children treated for S-ECC under general anesthesia (GA) has relapse with new carious lesions within 6-12 months post treatment. Improved clinical outcomes for S-ECC are likely to be realized through treatment strategies that are not a financial burden on health resources and focus on the infectious aspect of this disease[47].

As Caries is an infectious bacterial disease, its initiation and progression depend on the balance between demineralization and remineralization of the enamel. Fluoride works as a demineralization-reversing (remineralization) force and the use of fluoride has played a considerable role in the prevention of caries during the

past few decades. However, in individuals at high risk for caries if the bacterial challenge is high enough to overcome the benefits of fluoride therapy so antibacterial treatment to reduce their "bacteria challenge" may be proposed[46]. Thus gaining control of *S. mutans* infection in high risk children is accomplished in two phases-caries control by restoration of cavities followed by chemotherapeutic medication.[67].

Behaviours such as dental visits, use of fluoride and antimicrobial agents, oral hygiene and dietary practices can effect caries incidence throughout life [68]. A variety of chemotherapeutic agents have been examined for their ability to control oral micro organisms and to affect plaque formation. The main classes which have been tested are antibiotics, metal ions, enzymes, plant extracts and phenolic compounds.[69]

Recently the council on scientific affairs of the American Dental Assoitaion(ADA)[70] appointed an expert panel who recommended the use of varnish for children less than 6 years of age and varnish or gel for 6-18 years in children with moderate and high risk for dental caries . In a high caries risk population, where oral hygiene is poor and dentist are scarce, the application of varnishes might be very useful .[71]

Fluorides, which represent one of the most successful agents in caries prevention, have only limited antimicrobial effect .[7] The ability of some strains of streptococci to become refractory to fluoride tolerance may develop during prolonged topical fluoride therapy[72]. Hence need for an adjunct along with topical fluoride is emerging.[73]

The combination is thus helpful in reduction of caries to a greater extent than individually in accordance to other similar studies.[74-76] This is more important especially in patients with radiation caries,[77,30] high risk patients, medically compromised patients, the elderly or certain patients in whom carrying out restorative treatment would be difficult .[68]

"Caries Balance", a concept given by Featherstone[22] simplifies the balance between three pathological factors and three preventive factors for progression, inhibition or reversal of dental caries (figure 6). For caries prevention or reversal, it is necessary to effectively increase effect of one or more protective factors or to decrease the effect of one or more pathological factors. Thus caries can be controlled with reduction in acid producing bacteria like streptococcus mutans and increasing the protective factors.[22]

Traditionally topical fluorides have been used as antiplaque and anti-caries agents. They are known to inhibit the coherence of *S. mutans* at concentration as low as 0.001% .However dose calculations and toxicity due to possible ingestion remains a potential problem in the children of preschool age. It is also well established that the APF treatment enhances remineralization and repair of early lesions, but this effect was insufficient to overcome the severe caries challenge in high risk patients.[49]

To date, chlorhexidine has been the most frequently used topical antibacterial agent for caries prevention, but with limited success. Studies show that chlorhexidine products reduce the levels of *Streptococcus mutans* in the mouth, but its efficacy on lactobacilli (*lb*) is limited .[78,79] Besides, patient compliance is always a big challenge for chlorhexidine use because of its unpleasant taste and potential for tooth staining.[49] Hence, a better antibacterial is needed. Iodine has been recognized as a valuable antiseptic for more than a century. It appears to be a promising antibacterial for caries-associated bacterial infection and the combination of PVP-I and fluoride may serve as a promising caries-prevention agent for the

caries-active population because of its possible combination of bacteriostatic and demineralization-reversing effect as a whole. Antibacterial treatments such as povidone iodine, coupled with enhancement of remineralization by fluoride applications, can be shown effective in caries prevention in future studies such combined therapy could become an important public health measure.[49]

A total 200 subjects were selected from nearby government schools of Sangaredddy so as to minimize the losses of sample during the follow-up period. The area selection of sample is in consistent with Mauli Simartvir et al[49] in which he minimized the lost to follow-up by selecting children from a nearby school in the same geographic area.[49] The sample was divided into experimental and control group of 100 each. Experimental group received topical application of both 10% Povidone iodine and fluoride varnish while Control group received only fluoride varnish for every 3 month interval for a period of 1 year. The 3 months interval period was chosen is in consistent to studies of Milgrom et al,[54] ohnmar et al,[50] mauli simratvir,[49] and Ling zhan et al[39] in which they stated that one-time treatment with povidone iodine reduced mutans streptococci and lactobacilli levels for up to 3 months and other reason is that it is in correspondence with the usual application of fluoride varnish as recommended by American Dental association (ADA) for prevention of dental caries in primary dentition.[80]

Out of the total sample 12 children from the experimental and 8 children from the control group were lost to follow-up. In spite of best efforts, a certain percentage of losses to follow up surveys are inevitable. An Attrition rate of 20% per year is accepted in a longitudinal study [81] and our sample loss was within this limits. The reasons for the attrition are either children shifted from one school to other school during a new academic year or migration of their parents from one area to other area as most of the parents of the sample were agricultural labours.

Control group

Control group received 0.2ml of fluoride Varnish (Fluoritop SR, ICPA health products Ltd. Mumbai, India) as it is easily available and cost effective. It contains 50 mg sodium fluoride per ml equivalent to 22.6 mg of fluoride in slow release form.

In our study we used a fluoride varnish in the control group as on ethical background it is not acceptable not use pure control group by using the deionized water thereby depriving a group of children from getting benefited from caries preventive strategy.

Fluoride varnish is a concentrated topical fluoride with a resin or synthetic base and has been found to be the most effective cariostatic agent in the field of dentistry especially in pediatric dentistry [38]. Fluoride alters the physiochemical properties of teeth by making them more resistant to acid dissolution due to the formation of fluorapatite or fluorhydroxyapatite. It also increases the post eruptive maturation, enhances remineralization and inhibits demineralization.[82]Fluoride varnishes are quick and easy to apply and are less likely than gels to be swallowed by young children. Complete isolation was maintained during the application of varnish in accordance to Kochs[83] in vitro study which showed greater uptake of varnish on dry surface rather than wet surfaces. Varnish is hydrophobic and it adheres tenaciously to dry teeth and is unaffected by saliva or water when on the dry tooth.[84]

Fluoride exerts its cariostatic effect by its presence in the oral fluids bathing the dental hard tissues.[85,86] The main action of fluoride is to retard demineralization and promote remineralization of enamel and dentin by the uptake of calcium and phosphates of saliva.[72] · It also

inhibits glucose transport, carbohydrate storage, and extracellular polysaccharide formation by interfering with enolase enzyme in micro organisms.[72,73,87] .

Accurate application of the varnish to the teeth allows minimal contact with the oral mucosa. On an average 0.5ml of the varnish was used in the present study per application per child which is similar to that used in a study done in Canada by Clark[84] and Stamn[88] in 6-7 year old children and in india by Tewari et al [84] in 6-12 year old children. However a slightly higher amount of varnish per application per child was used in studies done by Zimmer et al [89] in 8 year old children (0.68ml). However the utilization of the varnish depends on viscosity, flow and rapidity with which it dries after application on the teeth, the number of teeth and size of the tooth. Less than 0.5ml of varnish is usually required to coat the teeth of a young child[90]. The children were instructed not to eat or brush his or her teeth for 1 hour.

Experimental group

Experimental group received 0.2ml of 10% PVP-iodine (1 percent active iodine, microshield, PVP-S, Johnson &Johnson, India) approved by the Food and Drug Administration (FDA) for topical use in the mouth. The exact amount of application of 10% povidone iodine was not standardized clinically. In the present study a total volume of 0.20 ml of iodine solution which was found to be sufficient during our pilot study was used- a dose that contains 2 mg of iodine, which is nontoxic when applied. The solution was applied for 4-5 minutes. This is in accordance with the study of Tanzer *et al*[17] who supported that Povidone-iodine was bactericidal at a concentration of 1% titratable iodine for *Streptococcus mutans* and *Actinomyces viscosus*, but was bacteriostatic for *Streptococcus sanguis* and *Actinomyces naeslundii*. The minimum time required for killing *Streptococcus mutans* and *Streptococcus sanguis* was 5 minutes while *Actinomyces naeslundii* and *Actinomyces naeslundii* required a minimum of 30 minute application. The amount of application of PVP I is also in consistent with the studies of ohnmar [50], Robert j berkowitz[53], Maryam S Amin[16], Lydia lopez[28] but in contrast with the study of Ling Zhan et al[39] in which one time of application of 2ml of 10% povidone iodine was done showing the reduction of mutans streptococci and lactobacilli levels for up to 3 months but this therapy failed to additionally reduce future caries formation over one year, indicating that repeated antibacterial treatments. So a repeated application 0f 0.2ml of 10% povidone iodine for every 3 months up to 1 year has been designed for present study.

Povidone Iodine or polyvinyl pyrrolidone-iodine is an iodophor and a broad spectrum antimicrobial agent, commonly abbreviated as PVP-I was discovered by American scientists H. A. Shelanski and M. V. Shelanski. PVPI was introduced to the pharmaceutical market as an antiseptic agent in the 1950's and is found to be more effective than other iodine formulations and was less toxic.[52]

Structure of PVP-I is 2-Pyrrolidinone, 1-ethenyl-, photopolymer, compound with iodine [91.](figure 7)

Properties

PVP iodine is a loose complex of elemental iodine with a neutral, amphipathic organic compound, poly vinyl pyrrolidone (PVP), which serves as a sustained release reservoir of iodine. PVP-I is a broad spectrum biocidal agent which is highly soluble than other iodine compounds and it is effective in the range of $_{p}$H 3 -6 with an average particle size ranging from 90 to 140µ.[52] Povidone iodine solution being a water soluble compound liberates iodine which has antimicrobial action. The slow

release of iodine from povidone iodine allows for long term antibacterial effect.[91]

Bio-Compatibility

PVP-I differs from iodine, in that it is less irritating to the skin and does not require iodides or alcohol to dissolve. PVP-I stains are water washable and exhibits markedly lower oral toxicity. The accidental ingestion of PVP iodine solution is much less hazardous. PVP-I is delivered in many forms including powders, gels, lotions, ointments, sprays and mousses. [50]

Composition of PVP-I

The 10% PVP-I solution contains 90% water, 8.5% polyvinyl pyrrolidone (PVP) and only 1% available iodine. Polyvinyl pyrrolidone, the hydrophilic polymer that acts as a carrier, does not have any intrinsic antibacterial activity but reduces irritability, and decreases the staining caused by pure iodine.[35]

Mode of Action

In the PVP-Iodine complex, the iodine does not exists as a single species, and infact several forms of iodine have been characterized:

- Available iodine: Contains all the iodine species which can be titrated with sodium thiosulfate
- Iodide: Negatively charged ion; necessary for the complexation of iodine
- Total iodine: Given by the sum of available iodine and iodide.
- Free Iodine: The type of iodine which can be extracted from aqueous PVP-Iodine solution.[94]

The determining factor of the bactericidal action of PVP-I remains the concentration of free iodine .Because of its affinity to the cell membrane it delivers free iodine (I2) directly to the bacterial cell surface. Iodine targets are located in the bacterial cytoplasm and cytoplasmic membrane, and its cidal action takes place in a matter of seconds.[52] Peter M Milgrom[54] suggested that as PVP-iodine (PVP-I) interferes with the ability of *Streptococcus mutans* to bind to tooth surfaces by disrupting the expression and production of glucosyltransferase. Thus, PVP-iodine makes it more difficult for the organism to maintain its place in the biofilm next to the tooth, which is required for the bacterial acids to damage the tooth surface.[77]

Biocidal action

The microbicidal action of PVP-Iodine is related to the non-complexed, freely mobile elemental iodine, I_2, the active form of which is polarized by water and hence can be considered to be Hydroxyl Iodide (H_2OI+) in its final state. This activated iodine reacts in electrophilic reactions with enzymes of the respiratory chain as well as with amino acids from the cell membrane proteins both located in the cell wall. As a result, the well-balanced tertiary structure necessary for maintaining the respiratory chain is destroyed and the microorganism irreversibly damaged. Consequently, PVP-Iodine has a nonspecific mode of action.[34]

Oro dental uses of PVP-I

Anti-Caries Action

In children suffering from early childhood caries, 10% povidone iodine applied in 3 month intervals over a period of one year has resulted in significant reduction in the rise of Streptococcus mutans levels. Reduction in counts in turn decreased the relapse of caries in these children [39 49]

Pre-procedural Rinse

Pre-procedural rinse with povidone iodine can reduce the level of oral microorganisms generated in aerosols or spatter during routine dental procedures [29 13] and can decrease the number of microorganisms introduced into the patient's bloodstream during invasive dental procedures. The American Heart Association suggests that

patients at risk for bacterial endocarditis use an antimicrobial mouth rinse before dental treatment.[92]

Anti-plaque action

Povidone iodine appears to have no significant plaque inhibitory activity when used as 1% mouthwash and 30 to 40 % overall reduction in aerobes and anaerobes occurred with the active preparation which was significant.[93]

Irrigant in Endodontics

Application of PVP-I solution as an endodontic irrigant was proposed based on its rapid antiseptic action against a broad range of microorganisms, low toxicity, hypoallergenicity, and greatly reduced tendency to stain dentin than other iodine containing antiseptics.[94] 10% PVP-I is often employed for tooth surface disinfection and operating field which includes tooth, rubberdam and clamp. 2% PVP-I killed all Candida albicans cells within 30 seconds, and a 10-fold dilution showed complete killing within 5 minutes.[71]

Caries recording was done at baseline, 6 months and 12 months. New carious lesions (decayed teeth dt) in primary dentition were recorded by using modified WHO (1968) index[58] and progression of the existing carious lesions was recorded by GJ Mount Site & Size classification.[59]

While recording the carious primary teeth in a patient few of them had decay in permanent teeth (DT) also but those scores were for descriptive purpose only but not for statistical analysis.

Mean decayed teeth in primary dentition

The present study shows the reduction of mean decayed teeth (dt) in experimental group when compared to control group indicating that Experimental group is more effective in reducing the number of decayed teeth compared to control group in primary dentition at both 6 months and 12 months follow up period. The reduction of mean decayed teeth in primary teeth is more pronounced in 12 months period indicating the repeated application combined treatment is more efficacious in high risk patients. These results are in consistent with the results of Caufield et al,[25] Lydia Lopez,[28] and Mauli Simratvir et al [49] but in contrast to Mary S Amin et al,[16], Ling Zhan et [39].

Several investigators using different animal models have suggested that smooth surface (buccal) caries are principally a Streptococcus mutans-related phenomenon, while sulcal (fissure) caries can be non- Streptococcus mutans dependent.[95,96]

The combined treatment of topical iodine and fluoride varnish is more effective in reducing the mean decayed than fluoride varnish alone can be explained by the fact that in combined treatment, topical iodine reduces smooth surface caries while fluoride varnish reduces sulcal caries and when used as a combination they have a synergistic effect of reducing caries.[28]

Caufield *et al* [25] showed that Iodine – potassium iodide solution was more effective in reducing the mean buccal caries score while Sodium fluoride was found to be more effective for sulcal sites. The inability of iodine to reduce fissure (sulcal) caries possibly reflected of its inability of iodine to be retained in the sulcus, its lack of penetration to the depth of microbial mass, and tendency of sulcus to be quickly recolonized following disinfection are overcome by adding the Fluoride varnish. Because the colonization of S. mutans is localized to the surfaces of the teeth, the topical application of antimicrobial agents has proven to be the most direct and effective method of adversely affecting this organism.[25]

Accordingly combination treatment was preferred in the present study based on selective action of Povidone–Iodine and fluoride varnish making it a beneficial antimicrobial agent to be used in high risk patients. Moreover, the additive antibacterial effect of NaF and

Iodine in combination suggests that these agents have independent mechanisms of antibacterial action. This assumption is reasonable in view of what is known about the antimicrobial properties of these agents. In addition, the ability of these two agents in combination to exert the desired antimicrobial effect allows clinicians to avoid several disadvantages associated with these agents when they are applied singly in higher concentrations.For example, the limited solubility of NaF in aqueous solutions precludes its formulation in concentrations exceeding 4%. Iodine on the other hand, causes irritation to the oral mucosa in concentrations exceeding 2%. When NaF and Iodine are used in combination and at a lower pH, however, these limitations can be avoided.[18]

Moreover, due to the limited exposure of the antimicrobial agents to the bacteria that is inherent with topical applications, bactericidal rather than bacteriostatic concentrations of antimicrobial agents are more effective in reducing the levels of cariogenic bacteria colonizing the tooth surfaces.[97]

Animal studies indicate that accumulation of Mutans streptococci are associated with frequent and prolonged consumption of cariogenic substrates and precede the onset of dental caries .[85,98,] These experimental observations support the notion that infants who are colonized by Mutans streptococci and who have feeding habits characterized by frequent and prolonged oral exposure to cariogenic substrates are likely to have a drastic increase in their oral MS populations. Such an increase is associated with a high risk for rampant dental caries. On this basis, it is reasonable to speculate that suppression of MS to non-pathogenic levels may decrease risk for caries. In this regard, iodine solutions are well known for their ability to suppress MS dental populations when topically applied to the teeth.[18,25,26] Collectively, the preceding narrative suggests that periodic topical application of an iodine solution to the dentition of children at high risk should suppress dental MS levels and in turn reduce risk for the development of caries.[26]

Combination therapy reduces the cost and cause less trauma to the young patients by early prevention of dental caries. Prevention is more effective as the patient shifts from high risk level to low risk level.[26]

Increment of dental caries in primary teeth

Mean increment of dental caries is higher in Control group compared to Experimental group at both 6 months and 12 months follow up period suggesting that combined treatment of polyvinyl pyrrolidone iodine and fluoride varnish is more effective than fluoride varnish alone in reducing the dental caries. These results are in consistent to the study of Milgrom et al,[54]Ohnamr et al ,[56] and Mauli simartvir [49] but in contrast to the studies of Azza el Housseiny,[36],Mariyam S Amin et al[16]

Simartvir et al[49] study showed that at 6 month follow up visit there was a mean rise of 68.02 in *Streptococcus mutans* counts from the post operative score in the control group compared to 0.84 in the children receiving topical antimicrobial. However the difference in the rise of bacterial counts of two groups was not statistically significant. At 12 month follow up visit there was a mean rise of 267.31 in *Streptococcus mutans* counts from the post operative score in the control group compared to 35.5 in the children receiving topical antimicrobial. While in the present study showed a significant incremental of dental caries between experimental and control group at both 6 months and 12 months follow-up period. The difference in the rise of increment of caries in two groups was statistically significant pointing out to the role of Povidone Iodine in suppressing the re-growth of these bacteria.[49]

Retention sites such as occlusal fissures, enamel cracks, or micro spaces between the dental restorations and the cavity walls of meanwhile untreated teeth might have caused re growth of *Streptococcus mutans* during the interval for next appointment.[49]

The reason for the incremental of dental caries is high levels of infection by cariogenic microorganisms or the establishment of poor nutritional practices may be determinants of caries progression.[53]

In the present study reduction in decayed teeth in experimental group may be due to the applications of the antimicrobial regimens, or improvement in oral hygiene.

In this regard, human[16] and animal[26] model studies indicate that topical iodine agents can significantly suppress dental levels of *Mutans streptococci*.

Dasanayake AP[27] attempted to reduce transmission of *MS* to infants by giving the mothers' dentitions six applications of Iodine and sodium fluoride at the time of the child's tooth eruption.[27]

Application of an iodine solution to the child's dentition significantly reduces the incidence of ECC in high-risk children. This preliminary finding has potential clinical significance and underscores the rationale for initiating larger and more in-depth clinical trials.[27]

Another recent study by Oggard et al[30] shown that the application of an antimicrobial varnish in combination with a fluoride varnish significantly reduced the number of *MS* in plaque during the first 48 weeks of treatment.[30]

Proportion of patients with progression of decay in **primary dentition**

Proportion of patients with increase in size of the decay are less in Experimental group when compared to Control group at both 6 months and 12 months time period with a statistical significance.

The 6 Month follow up results are in consistent to the study Caufield et a,l[25],Lydia Lopez,[28],Maryam s amin et a,[16] Ling Zhan et al[39] but in contrast to Mauli Simratvir et al. [49]

The 12 months follow up results are in similar to Milgrom et al,[54] Ohnamr et al,[50] Mauli Simratvir et al [49] and in contrast to the results of Maryam s amin et al.[16]

Results of Maryam s amin et al[16] demonstrated a significant decrease for *S mutans* counts, 6 months after restorative treatment, for all children. However, the decrease was not significantly greater for children who had received betadine than for the control children. The probable reason why betadine did not demonstrate as significant an effect on *S mutans* at 6 months as had been anticipated. "One-time" restorative treatment performed for all subjects under GA probably made a major contribution to decreasing plaque *S mutans* at 6 months following treatment that may have overwhelmed the antibacterial effect of betadine.[16]

But in the present study as no restorative treatment has performed the baseline count of streptococcus mutans are high as the patients are high risk for caries. combined treatment of PVP I & FV has reduced the count of streptococcus mutans significantly in the experimental group when compared to control group which received only fluoride varnish alone. The reason for the suppression of the progression of the existing decay is that povidone iodine redcues the s mutans count when applied

Previous studies on the effect of restorative treatment on levels of *S mutans* have produced equivocal results. Some investigators [99,100] suggest that successful routine restorative treatment does not alter numbers of *S mutans* while others have demonstrated that extensive restorative dental treatment effectively reduces the level of caries-

associated microorganisms for a period of at least 6 months.[100]

The present study showed that increase in size of the carious lesion in both the groups in spite of applications of topical iodine and fluoride varnish. These findings are in correlation to Ohnmar[50] et al study.

Positive outcomes have been demonstrated for PVP-I (betadine) in controlling the incidence of new carious lesions for children at risk of developing extensive caries.

In spite of repeated application (4 applications) of fluoride varnish in control group there is higher progression of existing carious lesion and development of new carious lesions are also seen. These results are in consistent with the studies of Lawrence[37] and Weinsten[15] showing that the need of antibacterial treatment.

According to the Ecological plaque hypothesis,[49] along with the alteration of the oral environment, bacterial species must either be eliminated from the oral cavity or when reduced must be prevented from returning to its pathological level to prevent dental caries. An antibacterial agent that is effective and also acceptable to young children can help to establish a favourable oral environment and stop the disease process.

None of the children in either group experienced any adverse effects secondary to PVP-iodine treatment. There was no staining of the teeth in the PVP-iodine plus fluoride cohort. None of the children complained about the taste of the PVPiodine. There were also no adverse effects unrelated to the treatments. These results are in consistent with the studies of Milgrom et al,[54]Ohnamr et al,[50] ,Caufiled et al,[25] Lydia Lopez[28] , Maryam s amin et al,[16] Robert J berkowitz et al,[53] ,Ling Zhan et al.[39] Furthermore, betadine was well-tolerated by the children, acceptable to parents, simple and quick to apply, and did not cause any staining of teeth. In fact, no negative side effects of betadine were noted. Varnish itself acts as a protective barrier to prevent the teeth from staining.[31]

Thus, 10% Povidone iodine and fluoride varnish which were easily available and cost effective, their combination can be used in high caries risk patients and in preventive programmes in both the public health and private practice settings in a country like ours, where preventive dental health programmes are still a far off reality for most children. The combined treatment of 10% Povidone iodine and fluoride varnish is more beneficial to these high carious risk patients who cannot afford a speciality dental treatment by preventing the number of new carious lesion and by arresting the progression of the already existing lesion.

This study results are generally consistent with studies of Peter M Milgrom et al,[54] ohnmar et al[50] suggesting that a combination treatment with antiseptics and FV is more effective than fluoride treatment alone.

Limitations of the study

Although well designed, none of the studies identified and controlled for factors such as socioeconomic status of the participants, dietary habits and fluoridation status of the residential areas and schools of the participants, dental visits, or use of topical or systemic antimicrobials. Though difficult to balance in a randomized controlled clinical trial, these confounders might have a significant influence on the clinical outcomes of the study. The return of *S. mutans* at a particular site to its original level can be explained on the basis of outgrowth of a few remaining viable cells at that site or by re-infection *via* the saliva.

To conclude, in developing countries that have limited means, more cost effective measures undertaken to eradicate disease are imperative. Its ease of availability and cost effectiveness coupled with benefits of rapid antimicrobial activity and decreased adverse effects

(except for few reports of hypersensitivity) indeed make Povidone- Iodine a chemotherapeutic agent of choice in home regimes

Certain uncontrolled external factors such as oral hygiene behaviour of children and dietary habits might have affected the results. To overcome these confounders the study design can be modified to a crossover design where by the children after oral rehabilitation could be followed up for a period of time and then the same children could receive topical antimicrobial thereafter. Furthermore the wash out effect of Povidone- Iodine after its withdrawal can be studied. Costs and benefits of treatment with Povidone-Iodine compared to other traditional antimicrobial agents also warrant further research.

Further studies can be done on a larger population for a longer follow up period with minimum subject drop outs to assess the duration, frequency and different concentrations of Povidone-Iodine; to identify the best possible concentration that can significantly improve the clinical outcomes in high risk children.

Summary

A comparative study was conducted to evaluate the combined effect of 10% povidone iodine and 5% fluoride varnish as topical anticaries agent in moderate to high caries risk children. 200 Children of age 4-7 years having decay in their primary molars were selected from government primary schools of Sangareddy. The sample was divided into experimental and control group of 100 each. Experimental group received topical application of both 10% Povidone iodine and fluoride varnish while Control group received only fluoride varnish. Topical application was done in both groups for every 3 month interval for a period of 1 year. Caries recording was done at baseline, 6 months and 12 months. New carious lesions (decayed teeth dt) in primary dentition were recorded by using modified WHO (1986) index and progression of the existing carious lesions was recorded by GJ Mount Site & Size classification. Results showed that Experimental group showed significant reduction in mean decayed teeth when compared to control group at both 6 month and 12 month interval period. (p value<0.001; Sig) (Table 3, Chart 3). Incremental of dental caries is less in Experimental group when compared to control group at both 6 month and 12 month interval period with a significant value (p <0.001; Sig value). (Table 4) (Chart 4). The conclusions drawn from the study are Combined topical treatment with 10% polyvinylpyrrolidone iodine followed with 5% sodium fluoride varnish is more effective than treatment with varnish alone in preventing dental caries in children and combined treatment is inexpensive and clinically simple and quick. Hence we recommended the use of combination of 10% Povidone iodine and fluoride varnish for better results especially in children with high caries risk.

Conclusion

The following conclusions were drawn from the study

1. Combined topical treatment with 10% polyvinylpyrollidone iodine followed with 5% sodium fluoride varnish is more effective than treatment with varnish alone.
2. PVP-Iodine is non-staining and acceptable to children.
3. Combined treatment is inexpensive and clinically simple and quick.

Further studies can be done on a larger population for a longer follow up period with minimum subject drop outs to assess the duration, frequency and different concentrations of Povidone-Iodine; to identify the best possible concentration that can significantly improve the clinical outcomes in high risk children.

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