ORIGINAL ARTICLE

Cross-sectional Study on White Spot Lesions and its Association with Dental Caries Experience among School Children

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Abstract

Aim: To evaluate the association of white spot lesions (WSLs) with existing dental caries experience and other clinical parameters among children aged 7–12 years.

Design: A cross-sectional comparative study on 407 children using Nyvad's caries diagnostic criteria was performed on the permanent first incisors and molars. Accordingly, they were grouped as cases (presence of caries) and controls (sound). The data pertaining to sociodemographic variables and clinical variables of oral hygiene index (OHI), gingival bleeding index (GBI), decayed, missing, and filled surfaces (DMFS-dmfs), eruption degree of first permanent molars, and number of WSLs were subjected to bivariate analysis and multiple logistic regression to identify the predictor variables for the caries lesion activity.

Results: Relatively higher DMFS-dmfs scores, the number of WSLs, GBI, and OHI were recorded among the cases. In multiple logistic regression analysis, WSL ≥ 1 (OR = 18.78; CI 9.74–36.21, $p = 0.0001$), DMFS-dmfs + WSL ≥ 20 (OR = 30.75; CI 1.8–525.28, $p = 0.0001$), GBI > 0.5 (OR = 8.46; CI 4.05–17.66, $p = 0.0001$); OHI > 1.2 (OR = 2.83; CI 1.11–7.23, $p = 0.03$) were found to be significant predictors for the cases.

Conclusion: It is important to be cognizant of the initiation of caries in children through the initial stages so that efforts can be pooled in towards prevention rather than extensive curative measures.

Clinical significance: In routine clinical examinations, WSLs are seldom detected. An insight into these lesions can help the dentists' to strategize the preventive measures enabling a reduction in total dental caries experience, burden of disease, and improved quality of life.

Keywords: Cross-sectional comparative study, Gingival bleeding index, Nyvad's caries diagnostic criteria, White spot lesions.

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Introduction

Dental caries, one of the most prevalent chronic diseases of the teeth, is progressively destructive with multifactorial etiology. In most industrialized countries, 60–90% of school children are affected and nearly 100% of the adult population is affected.[1] The WSLs are considered to be the initiation of caries progression, if taken into account for the clinical assessment of caries then hardly any individuals are truly unaffected.[2] However, detection and diagnosis of the WSLs can tip the fate of these in favor of arrestment by modifying the risk factors that may be associated like diet, improved plaque control, and appropriate use of fluorides.[3,4]

Diagnosing dental caries at an early stage is an intellectual process involving both the determination of the presence and the extent of the lesion with a thrust on the judgment of its activity.[5] Visual changes of the dental structure resulting from the demineralization process can be carefully observed by subjective interpretation of surface characteristics of integrity, texture, translucency/opacity, location, and color.[6] The WSLs being the first clinical expressions of demineralization occurring on the surface of enamel are located mostly in the regions of biofilm accumulation. When active, they are characterized by whitish/yellowish, opaque with loss of luster, and feels rough when probe is moved gently across. The inactive form appears to be whitish/brownish/black with a shiny, hard, and smooth texture.[4]

Nevertheless, the epidemiological studies on the prevalence of WSLs are limited as most of these are focused on caries indices like DMFT, which do not quantify the WSLs.[7] The traditional measurement of caries at the stage of cavitation can no longer suffice the changes in the current scenario where the population exhibits an overall slowing in the rate of caries progression.[8,9] Nyvad's caries diagnostic criteria based on activity assessment can be performed with a high reliability, even when noncavitated diagnosis are included. The assessment of the caries lesion activity, which includes the noncavitated stages of the caries and the DMF index together, can provide an overview of the extent of the caries experience of an individual.[4]

The polarization of dental caries spread especially over the lesser socioeconomic strata necessitates the need to predict the risk factors associated with the caries even at the early stage of a WSL.[10] Oral hygiene has often been assessed as a risk factor for carious lesion development.[11,12] Bacterial plaque, gingival

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bleeding, and other biological factors of the oral environment act as determining factors of dental caries, along with several behavioral and socioeconomic factors.

The aim of the study was set to evaluate the association of WSLs with the existing dental caries experience and other clinical and sociodemographic parameters among children aged 7–12 years in Bengaluru South, Karnataka, India. The identification of the risk factors affecting the initiation and progression of dental caries may help dentist to place the patient in a high-risk category, set shorter recall intervals, and subject them to preventive measures for the reversal. All the more, it facilitates opportunities to plan policies aimed at benefitting larger population giving emphasis to the younger children and ultimately contribute toward effectiveness of the various public health programs.

Materials and Methods

Ethical Considerations

The research was approved by the Ethics Committee of AECS Maaruti College of Dental Sciences and Research Centre, Bengaluru, India (ref. no. 336/2015-16). The investigator was calibrated by the experts in the department to perform the visual inspection by Nyvad's criteria. Cohen's kappa for intraexaminer reproducibility ranged from 0.82 to 0.86. The study adhered to the ethical protocols of obtaining the informed consent from the parent/caregiver and the assent from children of 7–12 years of age.

Study Design and Sample Selection

Using Nyvad's criteria, those who had the presence of cavitated/noncavitated caries on the permanent first incisors/molars were categorized as cases and those lesion-free on the respective teeth were controls. A pilot study carried out on 40 children in the conventional clinical settings presented a 50% prevalence rate for dental caries in the concerned population. Accordingly, the sample size was calculated to be 374 with 10% relative precision, 90% power, and 5% level of significance. The final proforma included demographic variables of age, gender, socioeconomic status (SES), and type of school and the clinical variables under study. A stratified random sampling was done to select the schools from the list available with the educational department of the state. In the present study, one government and two private schools from Bengaluru South zone were selected for data collection of children aged 7–12 years. The duration of the main study was about 20 days extending from October to November 2015, during which the required sample size was achieved. Children belonging to the selected age group, who signed the assent form and with erupted permanent first incisors/molars participated, while uncooperative children and those with systemic disorders were excluded. Children presenting with teeth fully laden with calculus, moderate/severe cases of fluorosis, clearly demarcated hypo-mineralization of smooth surfaces and orthodontic treatment were not included in the study. A tactile-visual examination under natural light in the school environment was performed using a mouth mirror and explorer/CPI probe as required for the respective indices recorded. A total of 407 school children were examined, of which 236 were categorized as controls and 171 as cases. Oral hygiene was assessed using the OHI (Green and Vermillion)[13] and GBI (Ainamo and Bay),[14] while for dental caries DMFs and dmfs (decayed, extracted, or filled surfaces) they were used for permanent and deciduous teeth, respectively (World Health Organization),[15] eruption degree of first permanent molars (Ekstrand et al.).[16] The number of WSLs (score 1 of Nyvad's criteria) was counted and recorded as D2. D1 (total of DMFS-dmfs) and D2 together were considered as the total expected risk for caries of the individual, as under favorable cariogenic environment the WSLs (D2) may progress to cavitation. The sociodemographic variables included the age, the gender, the type of the school and the SES using Kuppuswamy's scale.[17]

Statistical Analysis

The data were exported on a Microsoft Excel spreadsheet and were subjected to analysis using SPSS version 20.0. A bivariate analysis using Chi-squared test was performed to evaluate the relationship between the studied parameters. Multiple logistic regression analysis was carried out to examine the predictors independently associated with the outcome measures. Odds ratio was calculated with 95% confidence interval (CI), and significance level was considered as $p < 0.05$.

Results

Sociodemographic Characteristics (Table 1)

Among the 171 cases who presented with caries on permanent first incisors/molars, the gender distribution was more or less similar with 87 females and 84 males, and majority were above nine years of age (134), whereas the controls were represented by 130 females and 106 males, of whom 184 were aged above nine years. Higher proportion of the children belonged to the private schools and middle/lower middle category of Kuppuswamy's socioeconomic scale in both the groups under study.

Clinical Characteristics (Table 2)

The DMFS-dmfs, number of WSLs, total caries experience calculated as DMFS-dmfs + WSL were categorized into four subgroups, whereas GBI and OHI were dichotomized as detailed in Table 2. The eruption degree of the first permanent molars was assessed (score 0—unerupted, 1—appearance of some part of the occlusal surface, 2—the occlusal surface free of gingiva, and 3—functional occlusion) and were grouped according to the number of teeth that reached functional occlusion. A relatively higher DMFS-dmfs scores, number of white lesions, GBI, and OHI were observed among the children categorized as cases. The highest of 54.97% among 7–12 subgroup of DMFS-dmfs, 76.61% among 1–5 subgroup for the number of WSLs, and 68.42% in the low caries experience category was observed among the case group. Majority of children in both control and case group had all four molars in functional occlusion. Relatively higher mean values were observed for all clinical variables among the cases. The bivariate analysis of the cases and controls with all clinical variables chosen were found to be statistically significant.

Multiple Logistic Regression Analysis (Table 3)

Multiple logistic regression analysis was carried out to assess the predictors that were independently associated with the outcome measures. The children belonging to private schools showed a significant association (OR = 2.6; CI 1.38–4.91, $p = 0.0030$) with caries activity. The number of WSLs (OR = 18.78; CI 9.74–36.21, $p = 0.0001$), DMFS-dmfs + WSL $\geq$ 20 (OR = 30.75; CI 1.80–525.28, $p = 0.0001$), GBI > 0.5 (OR = 8.46; CI 3.18–4.05, $p = 0.0001$), and OHI > 1.3 (OR = 2.83; CI 1.35–1.11, $p = 0.0300$) were found to be significant predictors for the progression of caries.

An extended observation from the present study was the fact that among 171 cases with cavitation on their permanent teeth, 60%

Table 1: Comparison of cases and controls with sociodemographic variables

	Controls (sound on permanent incisors/molars)		*Cases (with caries)*		*Total*			
Variables	*n*	*%*	*n*	*%*	*n*	*%*	*Chi-square*	*p value*
Age								
≤9	52	22.03	37	21.64	89	21.87	0.0091	0.9239
>9	184	77.97	134	78.36	318	78.13		
Gender								
Male	106	44.92	84	49.12	190	46.68	0.7053	0.401
Female	130	55.08	87	50.88	217	53.32		
Socioeconomic status								
Upper SES	6	2.54	2	1.17	8	1.97	8.2746	0.0821
Upper middle	13	5.51	13	7.6	26	6.39		
Middle/lower middle	136	57.63	101	59.06	237	58.23		
Lower/upper lower	72	30.51	55	32.16	127	31.2		
Lower	9	3.81	0	0	9	2.21		
Type of school								
Government	90	38.14	52	30.41	142	34.89	2.6056	0.1065
Private	146	61.86	119	69.59	265	65.11		
Total	236	100	171	100	407	100		

Table 2: Comparison of cases and controls with clinical variables (bivariate analysis)

	Controls (sound on permanent incisors/molars)		*Cases (with caries)*		*Total*			
Variables	*n*	*%*	*n*	*%*	*n*	*%*	*Chi-square*	*p value*
DMFS-dmfs								
1–6	152	64.41	17	9.94	169	41.52	127.588	0.0001*
7–12	64	27.12	94	54.97	158	38.82		
13–20	16	6.78	39	22.81	55	13.51		
>20	4	1.69	21	12.28	25	6.14		
No. of WSLs								
Absent	171	72.46	18	10.53	189	46.44	161.8284	0.0001*
1–5	65	27.54	131	76.61	196	48.16		
6–10	0	0	18	10.53	18	4.42		
>10	0	0	4	2.34	4	0.98		
DMFS-dmfs + WSL** total								
Absent	102	43.22	0	0	102	25.06	128.2684	0.0001*
Low (1–10)	125	52.97	117	68.42	242	59.46		
Medium (11–20)	9	3.81	44	25.73	53	13.02		
High (21–30)	0	0	10	5.85	10	2.46		
No. of first permanent molars reaching functional occlusion								
0	2	0.85	0	0	2	0.49	14.7018	0.0054*
1	0	0	3	1.75	3	0.74		
2	19	8.05	27	15.79	46	11.3		
3	0	0	2	1.17	2	0.49		
4	215	91.1	139	81.29	354	86.98		
GBI***								
≤0.5	217	91.95	77	45.03	294	72.24	108.8407	0.0001*
>0.5	19	8.05	94	54.97	113	27.76		
OHI****								
0–1.2	225	95.34	113	66.08	338	83.05	60.2837	0.0001*
1.3–3.0	11	4.66	58	33.92	69	16.95		
Total	236	100	171	100	407	100		

*$p < 0.05$; **WSL, white spot lesions; ***GBI, gingival bleeding index; ****OHI, oral hygiene index

Table 3: Multiple logistic regression analysis of cases and controls by other variables

	Controls		*Cases*		*Odds*				
Variables	*n*	*%*	*n*	*%*	*ratio (OR)*	*SE*	*95% CI for OR*		*p value*
Type of school									
Government	90	38.14	52	30.41					
Private	146	61.86	119	69.59	2.6	0.84	1.38	4.91	0.0030*
SES									
Low	217	91.95	156	91.23					
High	19	8.05	15	8.77	0.7	0.37	0.25	1.99	0.505
DMFS-dmfs									
<20	232	98.31	150	87.72					
≥20	233	98.73	151	88.3	2.47	2.02	0.5	12.3	0.268
No. of WSLs**									
Absent	171	72.46	18	10.53					
≥1	65	27.54	153	89.47	18.78	6.29	9.74	36.21	0.0001*
DMFS-dmfs + WSL total									
<20	236	100	161	94.15					
≥20	0	0	10	5.85	30.75	12.25	1.8	525.28	0.0001*
Eruption degree									
Partial	21	8.9	32	15.79					
Full	215	91.1	139	84.21	0.59	0.26	0.25	1.39	0.228
GBI***									
≤0.5	217	91.95	77	45.03					
>0.5	19	8.05	94	54.97	8.46	3.18	4.05	17.66	0.0001*
OHI****									
0–1.2	225	95.34	113	66.08					
1.3–3.0	11	4.66	58	33.92	2.83	1.35	1.11	7.23	0.0300*

*$p < 0.05$; **WSL, white spot lesions; ***GBI, gingival bleeding index; ****OHI, oral hygiene index

presented with frank cavitation and 12.62% had all four permanent molars cavitated (Table 4). The WSLs within the range 1–5 were present in 74.76% of cases, and among those with cavitated molars, 86.41% had their permanent molars in functional occlusion. On comparison, more females and those above nine years of age presented with more cavities on their teeth.

Discussion

At an initial stage of dental caries, the mineral loss produces microporosities that can be recognized clinically by the formation of white, opaque, and rough areas. These WSLs inevitably develop into lesions with cavitation, if cariogenic environment persists and the mineral loss continues. Hence, the evaluation of the caries progression is as important as its detection. In the present study population, the females outnumbered the male children with majority of them above 9 years. The cavitated lesions appeared to be more among middle/lower middle category of SES of Kuppuswamy's scale and those belonging to the schools run by private management. Kuppuswamy's scale proposed in 1976 measured the SES of an individual based on three variables, namely, education, occupation of the head of the household, and income of the family.[17] Of the three variables, education and occupation of the head of the household do not change frequently with time. The steady inflation and the resultant devaluation of the rupee necessitate periodic revisions of the income variable.

The permanent first incisors and the molars were examined for their caries activity using Nyvad's criteria, as they erupt early and are exposed to the dynamic oral environment for a longer time accounting for a greater chance of caries attack.[18,19] Any sign of initiation of dental caries on the permanent first incisors/molars can be suggestive of the cariogenic potential of the oral environment. Caries intervention programs for the community can fetch its maximum benefits assured only if it is delivered to the public right from the younger age. Age group of 7–12 years enabled us to assess the caries on the permanent first incisors/molars assuming at least one year of survival in the dynamic oral environment. Moreover, age of 12 years is considered as the global indicator age by WHO for international comparisons and surveillance of disease.[8]

Visual examination alone has been shown to have a high specificity but low sensitivity and reproducibility.[20] Therefore, different criteria have been proposed to provide defined descriptors of different severity stages of caries lesions.[21] Nyvad's system is a reliable method for activity assessment of noncavitated and cavitated caries lesions.[4] According to this system, the examination is based only on clinical features of the surface (color, opacity, and presence of discontinuities or cavitations), classifying the lesion as inactive or active. A ball-ended probe is used to gently draw across the surface in order to assess its texture (rough or smooth) and also to remove the biofilm. If the lesion is active/cavitated, operative treatment can be recommended, whereas if active/noncavitated then preventive treatment can be recommended. An important aspect of caries detection is that the surface must be dry because saliva can mask differences in the reflection of light between carious and healthy tooth structure, hindering the observation of changes in color and brightness on the enamel surface. In the epidemiological settings, drying a tooth surface is not an easy task

Table 4: Distribution of clinical parameters for Nyvad score 3 (with frank cavitation)

Variables	*No. of samples*	*% of samples*
Number of teeth with score 3		
1	49	47.57
2	29	28.16
3	12	11.65
4	13	12.62
Oral hygiene index		
0–1.2	69	66.99
1.3–3.0	32	31.07
3.1+	2	1.94
Eruption degree		
Partial	14	13.59
Full	89	86.41
Gingival bleeding index		
≤0.5	38	36.89
>0.5	65	63.11
DMFS-dmfs		
1–6	58	56.31
7–12	28	27.18
13–20	17	16.5
White spot lesions		
Absent	11	10.68
1–5	77	74.76
6–10	12	11.65
>10	3	2.91

to accomplish; but satisfactory results can be obtained with the use of chip blower and drying for 10 seconds.

For treatment decisions, it is imperative that the diagnosis should also express the individual patient's caries activity, which may be defined as the sum of new caries lesions and the enlargement of existing lesions during a given time.[22] DMFS-dmfs index can provide us with the past/present caries experience of the patient.[18] Thus, in this research, we considered the total caries experience by summing up the number of clinically detectable active WSLs (score 1 of Nyvad's criteria) together with the existing dental caries as represented by DMFS-dmfs. The study results positively point towards the association of the other clinical parameters of poor oral hygiene, presence of gingival bleeding, full eruption of first permanent molars, the number of WSLs, and total DMFS-dmfs with the progression of dental caries.

The results of the present study are in agreement with those of Quaglio et al. and Ferreira et al., where the age and gender showed no statistically significant association with the presence of active carious lesion.[18,23] On the contrary, studies by Lo, Schwartz, and Wong observed that girls presented significantly better results than boys with regard to caries regression.[24] The results showed an increasing trend for caries affected teeth in children studying in the privately managed schools. In the present study, about 60% of the cases belonged to middle/lower middle category of SES that determines the purchasing power and the lifestyle of the families. These changes considerably influence the diet pattern too, with increased dependency on the packed and processed food that might attribute to increase in caries prevalence. Supportive scientific literature regarding the factors that influence children's oral health is described at length by de Castilho and ascertain the role of parental knowledge, attitude, and SES on oral health of their children.[25] However, the present results did not show any significant association with SES and type of school. Lower SES was not linked with high caries experience in another study by Naidu et al.[26]

A relatively higher DMFS-dmfs scores, the number of WSLs, DMFS-dmfs + WSL, OHI, and GBI were recorded for the children who had caries on their permanent first incisors/molars. The present results showed that nearly 68% of the children with caries on the first permanent incisors/molars presented with a score of DMFS-dmfs and WSLs less than 10. It can be observed among the control group that, higher the total score, lesser the number affected. This result showed a statistically significant association and is in accordance with the studies by Kassawara et al. and Jain et al.[27,28] While activity reflects the dynamic nature of the dental caries, DMFS-dmfs corresponds to the past and present caries experience. Hence, it can be inferred that the presence of active caries lesions in other teeth is more related to the presence of active caries on the permanent first incisors/molars. In the present study, the OR of occurrence of active caries lesions was very high with the increase in DMFS-dmfs and WSL score.

The present study also asserts that the oral hygiene status and GBI could serve as a significant predictor for the progression of dental caries. The studies conducted by Ferreira et al. detected a positive and highly significant correlation between a high plaque index and enamel caries (OR 2.04; CI 1.86–3.47) and dentin caries (OR 3.18; CI 2.26–4.47).[23] Similar associations of poor oral hygiene with a higher risk of developing caries (OR 3.59; CI 2.53–5.06) were reported from the studies by Retnakumari et al. in children between 6 years and 12 years of age.[29] On the contrary, the studies by Etty on 548 children of 4–6 years of age, failed to detect an association of OHI with the progression of lesions, which could be attributed more to the intervention of fluorides.[30]

Gingival bleeding is a consequence of the presence of matured plaque, which may also be associated with the occurrence of lesion activity. In the present study, both GBI and OHI were found to be predictors for the occurrence of caries activity, which is in agreement with the studies by Ogaard et al.[11] Ferreira et al. in two of his studies had ascertained that the longer the biofilm remains in contact with the tooth surface, the greater is the chance for a high GBI, which in turn can be a risk factor for the progression of the carious lesion.[10,23]

Though the dental community takes pride on the efforts that have reduced the dental caries, it still remains alarming to see the disparities in the caries prevalence. We tried to explore the distribution of cavitated lesions along the isle of variables chosen for the present study. It was observed that nearly half of the cases had at least one permanent first molar teeth with frank cavitation and more than a quarter of the cases had two cavitated molars. This is a matter of concern in that, hardly within five years of its eruption, these teeth have progressed toward the cavitation. It was also observed that the DMFS-dmfs, OHI, GBI, and the number of WSLs were all considerably high for those children with cavitated teeth. The need for a meticulous oral hygiene improvement measure is to be emphasized at this juncture. The fact would also strive us to think of educating the parents and teachers on oral health so that it can be imparted in its best way to the future generations.

Longitudinal studies on a larger sample size are recommended to analyze the duration and severity of progression of active WSL to frank cavitation. In a country like India, where the dental services are underutilized due to very many reasons as that of impinging poverty, lack of awareness, inaccessibility to the services, such

studies would add sufficient weightage to think and enact on the grounds of preventive oral health services.

Conclusion

In conclusion, the number of WSLs, DMFS-dmfs, GBI, and OHI are significant predictors for the dental caries. A better understanding of initial caries, which is represented by the WSLs can enable better intervention and interrupt the progression of carious lesion and the use of invasive techniques. It is important from a public health point of view to be cognizant of the deterioration of the level of oral health, especially of children so that efforts can be pooled in toward the prevention of these problems.

Clinical Significance

In routine clinical examinations, WSLs are seldom detected. Any treatment-planning strategy will fetch its maximum benefit if these lesions are also incorporated along with the frank cavitation. The dentist can strategize the preventive measures, thus enabling a reduction in total dental caries experience, burden of disease, and improved quality of life.

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