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Original Article

Effects of graded preventive measures on dental caries prevention in young children susceptible to caries

Hua Dong[1], Zhaogao Zhang[2]

[1]*Department of Pediatric Dentistry, Jiading District Teeth Disease Prevention and Treatment Institute, Shanghai, China;* [2]*Department of Oral Surgery, Jiading District Teeth Disease Prevention and Treatment Institute, Shanghai, China*

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Abstract: Objective: To investigate the effects of graded preventive measures in managing dental caries among young children. Methods: A total of 319 children from three consecutive terms in the same grade enrolled in a public kindergarten (October 2019 to July 2021) were selected as the observation group. Oral health examinations were conducted biannually. Based on caries susceptibility test results, children were categorized into low risk (0-0.5 scores), moderate risk (1.0-1.5 scores), and high risk (2.0-3.0 scores). Preventive measures included: Low-risk group: Maintaining oral hygiene and semi-annual fluoride application. Moderate-risk group: Fluoride application every 3 months and enhanced health education. High-risk group: Weekly fluoride applications for 3 consecutive weeks, followed by monthly fluoride applications. Another 322 children from three similar classes in a comparable kindergarten were assigned as the control group, receiving fluoride applications every 6 months. The following were compared between the two groups: caries susceptibility test results, caries incidence, soft mucinous deposit detection rates, caries indicators, and changes in oral hygiene habits. Results: After 3 years of intervention, the proportion of low-risk children in the observation group significantly increased, while moderate- and high-risk proportions decreased compared to the control group (all $P < 0.05$). Caries incidence and soft mucinous deposit detection rates in the observation group were significantly lower at 1, 2, and 3 years post-intervention than in the control group (all $P < 0.05$). Key caries indicators-including decayed teeth (dt), missing teeth (mt), filled teeth (ft), decayed, missing, and filled teeth (dmft), decayed surfaces (ds), missing surfaces (ms), filled surfaces (fs), and decayed, missing, and filled surfaces (dmfs)-were significantly better in the observation group after 3 years (all $P < 0.05$). The observation group also showed significant improvements in oral hygiene habits (use of fluoride toothpaste, brushing frequency, brushing duration, sugary food intake frequency, food intake before sleep, gargling after meals, and oral examination intervals) compared to the control group (all $P < 0.05$). Conclusion: Graded preventive measures effectively reduce dental caries risk, incidence, and soft mucinous deposits in young caries-susceptible children while promoting better oral hygiene habits. These measures are highly recommended for clinical application.

Keywords: Graded prophylaxes, younger caries-susceptible children, caries susceptibility, caries, oral hygiene habits

Introduction

Dental caries is a chronic, progressive oral disease characterized by the destruction of the hard tissues of the teeth, primarily caused by bacterial activity [1, 2]. Younger children are particularly susceptible due to the immaturity of their oral protective functions, underdeveloped immune systems, and unique dietary habits [3, 4]. Globally, the prevalence of dental caries in this age group ranges from 5% to 94% [5]. Dental caries not only impairs chewing, nutritional absorption, and language development but can also worsen psychological well-being and lead to severe systemic diseases. Compared to other age groups, younger children exhibit a higher caries prevalence, likely attributable to eating habits, food composition, oral hygiene practices, and the anatomic and histologic characteristics of primary teeth [6].

Given its impact on growth, development, and overall health, the accurate assessment of caries risk, identification of high-risk children, and

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implementation of individualized prevention and treatment programs have become critical areas of research in caries control and child health [7].

In recent years, treatment for children's oral diseases has shifted toward early caries diagnosis and preventive measures. Caries risk prediction, particularly the screening of high-risk children followed by tailored preventive interventions, is essential for optimizing public health resource allocation and effectively reducing childhood caries incidence [8, 9].

The graded prevention strategy, based on Newman's system theory, emphasizes holistic patient care by considering physiological, psychological, spiritual, and social factors. This approach recommends implementing preventive measures tailored to the patient's specific needs to enhance self-care awareness and recovery. Studies have demonstrated its effectiveness in improving self-management and quality of life among patients with coronary artery disease undergoing percutaneous coronary intervention (PCI) [10]. However, its application in pediatric dental caries prevention remains largely unexplored.

As a prevention model rooted in individual risk assessment, the graded prevention strategy focuses on targeted interventions aligned with the caries risk levels and characteristics of children at different ages. These interventions encompass multi-level and multi-faceted measures, including oral health education, regular dental check-ups, and fluoride application [11].

This study investigates the effectiveness of graded preventive measures on caries prevention in younger children with caries susceptibility. By analyzing relevant data, the study aims to provide scientific evidence for developing more accurate and effective oral health management for children.

Materials and methods

General information

This retrospective study included 319 children from three consecutive terms in the same grade at a public kindergarten (October 2019 to July 2021) as the observation group. Another 322 children from three terms in the same grade during the same period at another public kindergarten in the region served as the control group.

Inclusion criteria: (1) Children aged 3-5 years with normal growth and development, without abnormalities in expression or cognition. (2) All primary teeth fully erupted before enrollment. (3) Healthy periodontal tissues at enrollment, without gingival redness, swelling, or bleeding. (4) Children able to cooperate with oral examinations and interventions.

Exclusion criteria: (1) Presence of varying degrees of caries in primary molars. (2) Dental developmental abnormalities such as enamel hypoplasia or congenital tooth defects. (3) Inability to follow up or cooperate with treatment. (4) Allergy to fluorine or fluoride.

This study was approved by the Ethics Committee of Jiading District Teeth Disease Prevention and Treatment Institute, Shanghai (No. 2018-205).

Methods

Children in the control group received routine fluoride applications every six months, following these steps: (1) Tooth cleaning: Teeth were thoroughly brushed with the assistance of parents and teachers. Each tooth surface was cleaned using cotton swabs. (2) Moisture barrier treatment: Tooth surfaces were dried and moisture-proofed with cotton balls to ensure a moisture-free surface. (3) Fluoride application: A fluoride protectant (Lot No. 20192171978, 0.4 ml, Ivoclar Vivadent, Switzerland) was applied evenly to the surfaces of anterior and other teeth using a small brush. (4) Post-application cautions: Sodium fluoride was avoided on an empty stomach. Fluoride was applied carefully, avoiding gums or oral mucosa.

Application was delayed if gum bleeding or mouth ulcers were present.

After application, children were supervised to avoid rinsing, drinking, or eating for 1 hour and advised not to chew hard foods for 4 hours. Brushing was not allowed the night after application.

All procedures were conducted by a standardized team of dental professionals who received uniform training before the study began.

Children in the observation group underwent graded preventive measures: (1) Oral health education: Parents attended lectures emphasizing the importance of oral health. They were guided to help children with brushing, flossing, and rinsing according to professional instructions. (2) Oral health checkups: Regular checkups were conducted at the start of each semester. (3) Graded prevention based on caries susceptibility tests: Low-risk children (score < 0.5): Maintained good oral hygiene and received fluoride treatment every six months. Medium-risk children (score 1.0-1.5): Received fluoride treatment every three months, and health education for parents and children was reinforced. High-risk children (score > 1.5): Received fluoride once a week for three consecutive weeks, followed by monthly fluoride treatments. The oral caries status was then reassessed. (4) Targeted follow-up measures: Intensive brushing: Improving brushing technique and frequency. Fissure sealing: For teeth prone to caries. Veneer polishing: Removal of soft mucinous deposits and treatment of minor demineralization. Caries filling: Treating existing carious cavities. Preformed crown: Protecting treated teeth from further damage.

Observed indicators

Routine oral examinations and Cariostat caries susceptibility tests were conducted for both groups once before the intervention and again 3 years after the intervention.

Oral Examination was conducted under natural light using an orofacial microscope and a No. 5 dental probe for visual inspection and probing.

A standardized Cariostat caries susceptibility test kit (Beijing Gangda Medical Technology Co., Ltd.) was used.

Samples were collected using disinfectant swabs provided in the kit. Swabs were wiped 3-5 times on the buccal side of the maxillary molars and the labial side of the lower anterior teeth near the neck of the teeth to gather mixed soft scale and plaque samples from the tooth surface.

Test results were color-coded as follows: 0.5: Dark green; 1.0: Light green; 1.5: Yellow-green; 2.0: Light yellow-green; 2.5: Light yellow; 3.0: Yellow.

Caries activity test (CAT) values were categorized as: Low risk: CAT < 1.0; Medium risk: CAT 1.0-1.5; High risk: CAT > 1.5.

Caries incidence and soft mucinous deposit detection rates were evaluated at baseline and at 1, 2, and 3 years post-intervention.

Caries were assessed in molar teeth using a probe to examine occlusal, labial, lingual, and adjacent surfaces.

Caries were defined as visible decay on smooth surfaces, grooves, pits, sub-enamel destruction, or lesions with a detectable bottom or soft cavity wall.

Caries Indicators were collected before the intervention and 3 years after the intervention. Indicators included: Number of decayed teeth (dt). Number of teeth missing due to caries (mt). Number of teeth filled due to caries (ft). Surfaces of decayed teeth (ds). Surfaces of missing teeth (ms). Surfaces filled due to caries (fs).

Calculations: Decayed, missing, and filled teeth (dmft) = dt + mt + ft. Decayed, missing, and filled surfaces (dmfs) = ds + ms + fs.

Questionnaire on oral hygiene and dietary habits: Administered after 3 years of intervention.

Survey topics included: Use of fluoride toothpaste. Frequency of brushing. Duration of each brushing session. Frequency of sugar-containing food intake. Eating before bedtime. Rinsing after meals. Intervals between oral examinations.

Statistical methods

All clinical data were analyzed using SPSS version 23.0. The measured data were expressed as mean ± standard deviation (SD). Independent t-tests were used for comparisons between two groups.

One-way analysis of variance (ANOVA) followed by Bonferroni post hoc tests was applied for comparisons among three or more groups. The counted data were expressed as percentages

Table 1. Comparison of general information between two groups [Mean ± SD, *n* (%)]

Group		Observation group (n=319)	Control group (n=322)	χ^2/t value	*P* value
Gender	Male	168 (52.66)	170 (52.80)	0.305	0.630
	Female	151 (47.34)	152 (47.20)		
Age (years)		4.22±0.51	4.13±0.54	0.295	0.768
Annual household income (X 10,000 Yuan)	< 5	60 (18.81)	62 (19.25)	0.217	0.685
	5-10	188 (58.95)	193 (59.94)		
	> 10	71 (22.25)	67 (20.81)		
Feeding patterns within 6 months	Exclusive breastfeeding	96 (30.09)	103 (31.99)	0.317	0.562
	Exclusive artificial feeding	64 (20.06)	71 (22.05)		
	Mixed feeding	159 (49.85)	148 (45.96)		

Table 2. Comparison of Cariostat caries susceptibility test results in young children between the two groups before and after intervention [n (%)]

Group	n	Before interventions			3 years after interventions		
		Low risk	Middle risk	High risk	Low risk	Middle risk	High risk
Observation group	319	59 (18.50)	106 (33.23)	154 (48.27)	156 (48.90)	62 (19.44)	101 (31.66)
Control group	322	63 (19.57)	112 (34.78)	147 (45.65)	108 (33.54)	87 (27.02)	127 (39.44)
χ^2 value		0.119	0.172	0.443	15.613	5.164	4.232
P value		0.730	0.678	0.506	0.000	0.023	0.040

or case counts. Group comparisons were done using the χ^2 test.

A *p*-value of < 0.05 was considered statistically significant.

Results

Comparison of general information

As shown in **Table 1**, there were no significant differences between the observation group and the control group in terms of gender, age, annual household income, or feeding patterns within the first six months (all P > 0.05). These groups were therefore comparable.

Comparison of Cariostat caries susceptibility test results

Before the intervention, no significant differences were observed between the groups regarding the proportions of children at low, medium, and high risk for caries susceptibility (all P > 0.05). At 3 years post-intervention, the proportion of children at low risk in the observation group was significantly higher than that of the control group, while the proportions of medium- and high-risk children were significantly lower in the observation group (all P < 0.05). Details are presented in **Table 2** and **Figure 1**.

Comparison of caries incidence and soft mucinous deposit rates

Figure 2 illustrates the trends in caries incidence and soft mucinous deposit rates in both groups over the three years following the intervention, showing a gradual increase in both groups. **Table 3** indicates that there were no significant differences in caries incidence or soft mucinous deposit rates between the two groups before the intervention (both P > 0.05). However, at 1, 2, and 3 years post-intervention, the observation group had significantly lower rates of caries and soft mucinous deposits compared to the control group (all P < 0.05).

Comparison of caries indicators

As shown in **Table 4**, there were no significant differences in caries indicators (dt, mt, ft, ds, ms, fs, dmft, and dmfs) between the two groups prior to the intervention (all P > 0.05). At 3 years post-intervention, the observation group exhibited significantly lower values for all indicators (dt, mt, ft, ds, ms, fs, dmft, and dmfs) compared to the control group (all P < 0.05).

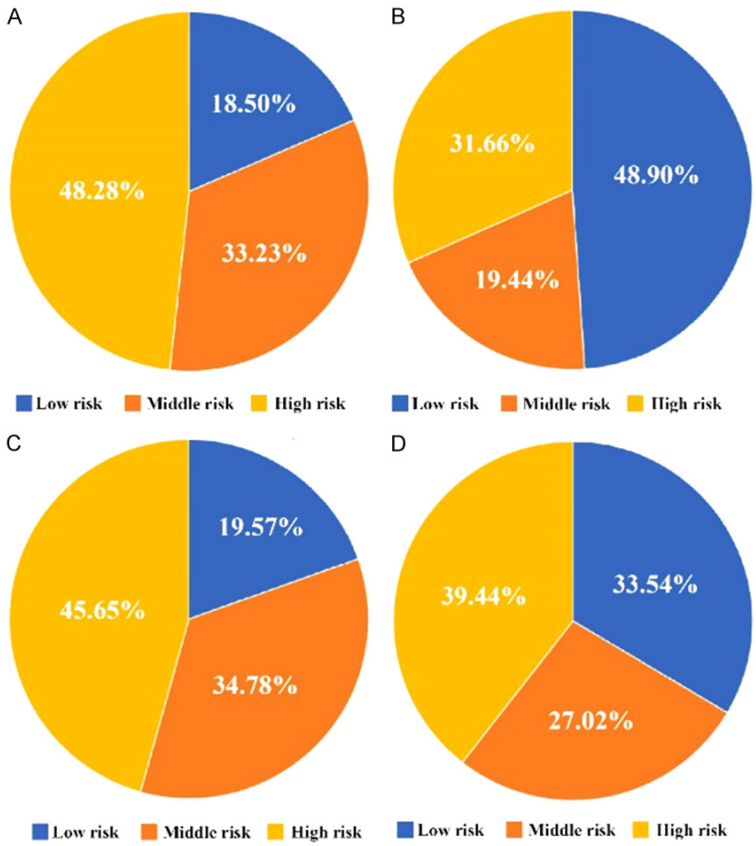

Figure 1. Comparison of Cariostat caries susceptibility test results between the two groups before and after intervention. A: The Cariostat caries susceptibility test results before intervention in the observation group. B: The Cariostat caries susceptibility test results 3 years after intervention in the observation group. C: The Cariostat caries susceptibility test results before intervention in the control group. D: The Cariostat caries susceptibility test results 3 years after intervention in the control group.

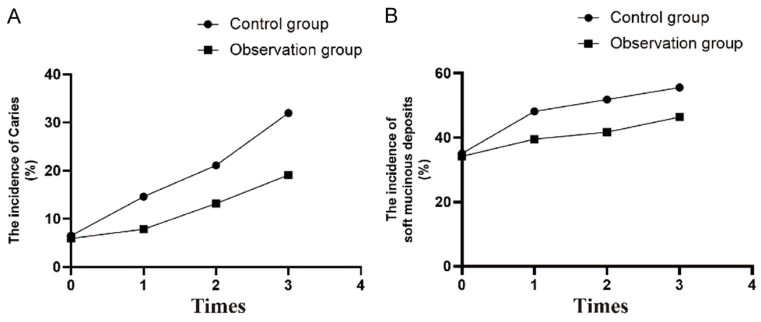

Figure 2. Trends for the incidences of caries and soft mucinous deposits in the two groups. 0 in X-axis: Before intervention; 1 in X-axis: 1 year after intervention; 2 in X-axis: 2 years after intervention; 3 in X-axis: 3 years after intervention.

Comparison of oral health and dietary habits

Three years after the intervention, significant differences were observed between the two groups regarding oral health and dietary habits. These included the use of fluoride toothpaste, brushing frequency, brushing duration, sugary food intake frequency, food intake before sleep, rinsing after meals, and the interval time for oral examinations (all $P < 0.05$), as detailed in **Table 5**.

Discussion

Dental caries is a prevalent oral disease affecting both children and adults [2, 12, 13]. Younger children are particularly susceptible to dental caries due to poor dietary habits and inadequate oral hygiene practices. Current preventive measures for dental caries in younger children include regular fluoride applications, health education, and home oral hygiene instructions [14-16]. While these strategies can reduce the incidence of dental caries to some extent, they often fail to account for individual variability and specific needs [17].

For instance, children with higher caries susceptibility may require more frequent and intensive preventive measures, while low-risk children may not need such interventions. The lack of individualized preventive strategies may lead to inefficient allocation of resources, with excessive attention given to low-risk individuals and insufficient support for high-risk individuals. This imbalance may result in some children receiving unnecessary interventions while others are inadequately supported.

To address these limitations, this study implemented a graded prevention strategy for younger children with caries susceptibility. Children were categorized into different risk levels based

Table 3. Comparison of the incidence of caries and soft mucinous deposits before and after intervention between the two groups [n (%)]

Item	Time	Observation group (n=319)	Control group (n=322)	χ^2 value	*P* value
The incidence of Caries	Before intervention	19 (5.96)	21 (6.52)	0.088	0.767
	1 year after intervention	25 (7.84)	47 (14.60)	7.343	0.007
	2 years after intervention	42 (13.17)	68 (21.12)	7.128	0.008
	3 years after intervention	61 (19.12)	103 (31.99)	13.931	< 0.001
The incidence of soft mucinous deposits	Before intervention	109 (34.17)	113 (35.09)	0.060	0.806
	1 year after intervention	126 (39.50)	155 (48.14)	4.857	0.028
	2 years after intervention	133 (41.69)	167 (51.86)	6.658	0.010
	3 years after intervention	148 (46.39)	179 (55.59)	5.422	0.020

Table 4. Comparison of indicators for caries between the two groups before and after intervention ($\bar{x} \pm s$)

Item	Times	Observation group (n=319)	Control group (n=322)	t value	*P* value
dt	Before intervention	0.83±0.31	0.85±0.33	0.791	0.429
	3 years after intervention	1.16±0.39	1.01±0.35	5.126	0.000
mt	Before intervention	0.63±0.19	0.65±0.18	1.368	0.172
	3 years after intervention	0.55±0.13	0.62±0.16	6.076	0.000
ft	Before intervention	0.46±0.15	0.48±0.16	1.632	0.103
	3 years after intervention	0.51±0.18	0.59±0.19	5.471	0.000
dmft	Before intervention	1.85±0.36	1.83±0.39	0.675	0.500
	3 years after intervention	2.33±0.44	2.12±0.41	6.252	0.000
ds	Before intervention	0.96±0.38	0.93±0.37	1.013	0.312
	3 years after intervention	1.27±0.46	1.09±0.44	5.063	0.000
ms	Before intervention	0.84±0.26	0.81±0.23	1.548	0.122
	3 years after intervention	0.76±0.17	0.88±0.24	7.299	0.000
fs	Before intervention	0.64±0.15	0.66±0.16	1.632	0.103
	3 years after intervention	0.58±0.13	0.68±0.17	8.360	0.000
dmfs	Before intervention	1.88±0.34	1.86±0.32	0.767	0.443
	3 years after intervention	2.36±0.42	2.15±0.45	6.107	0.000

Note: dt: decayed teeth; mt: missing teeth due to caries; ft: filled teeth due to caries; ds: decayed surfaces; ms: missing surfaces due to caries; fs: filled surfaces due to caries; dmft: decayed missing and filled teeth; dmfs: decayed missing and filled surfaces.

on caries susceptibility test results, and tailored prophylactic measures were applied accordingly. Several advantages of the graded prevention approach was observed: (1) Personalized prevention plans: Tailored measures ensured more precise and effective prevention for each child. (2) Targeted attention for high-risk children: High-risk children received closer monitoring and support, leading to more effective and efficient preventive outcomes. (3) Optimized resource allocation: Healthcare resources were distributed more rationally, focusing on individuals who needed them most. (4) Improved efficiency: By prioritizing resource allocation, the overall efficiency of prevention efforts were enhanced [18-20].

The study revealed that after implementing graded prevention, the proportion of low-risk children in the observation group increased significantly, while the proportions of medium- and high-risk children decreased. Comparisons between the observation and control groups demonstrated that the caries rate and soft scale detection rate were significantly lower in the observation group at 1, 2, and 3 years post-intervention. Furthermore, caries indicators-including dt, mt, ft, dmft, ds, ms, fs, and dmfs-

Table 5. Comparison of conditions for oral health habits and dietary habits at 3 years after intervention between the two groups [n (%)]

Item		Observation group (n=319)	Control group (n=322)	t/χ^2 value	*P* value
The use of fluoride toothpaste	Yes	152 (47.65)	107 (33.23)	13.836	< 0.001
	No	167 (52.35)	215 (66.77)		
The frequency of brushing	≥ 2 times per day	131 (41.07)	101 (31.37)	6.906	0.032
	1 time/d or not every day	142 (44.51) 46 (14.42)	161 (50.00) 60 (18.63)		
The brushing time every time	> 3 min	141 (44.20)	113 (35.09)	8.709	0.013
	2-3 min	122 (38.24)	125 (38.82)		
	< 3 min	56 (17.55)	84 (26.09)		
Sugary food intake frequency	≥ 1 time/d	94 (29.47)	138 (42.86)	12.441	< 0.001
	< 1 time/d	225 (70.53)	184 (57.14)		
Food intake before sleep	Never	64 (20.06)	41 (12.73)	12.673	0.002
	1-2 time/week	174 (54.55)	162 (50.31)		
	≥ 3 times/weeks	81 (25.39)	119 (36.96)		
Gargling after meals	≥ 2 times/d	104 (32.60)	69 (21.43)	11.321	0.003
	1 time/d	133 (41.69)	144 (44.72)		
	Never	82 (25.71)	109 (33.85)		
Interval time for oral examination	< 3 months	146 (45.77)	117 (36.34)	13.998	0.001
	3-6 months	113 (35.42)	104 (32.30)		
	≥ 6 months	60 (18.81)	101 (31.37)		

were significantly better in the observation group after 3 years of intervention.

By focusing on middle- and high-risk children, graded prevention not only reduced caries risk but also improved the overall oral health of younger children. This approach demonstrated a rational allocation of medical resources and enhanced the efficiency of their use. Graded prevention measures show potential for reducing caries risk in high-risk children while promoting better oral health outcomes for all younger children [21-23].

This study also identified significant differences in oral hygiene and dietary habits between the two groups. These differences included the use of fluoride toothpaste, frequency of brushing, duration of brushing, frequency of sugary food intake, eating before bedtime, rinsing after meals, and intervals between oral examinations. These findings further confirm that graded prophylaxis not only directly reduces the risk of caries but also promotes the development of good oral hygiene habits, consistent with previous studies [24].

However, this study has certain limitations, including a relatively small sample size and the absence of long-term follow-up to assess recurrence. Future research should aim to address these limitations through larger-scale studies and extended follow-up periods for more comprehensive insight.

In conclusion, graded prevention measures enhance the accuracy and efficiency of caries prevention while enabling a more rational allocation and use of medical resources. This approach, based on individual caries susceptibility, not only significantly reduces caries risk in children but also fosters the development of good oral hygiene habits, providing long-term protection for their oral health.

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Disclosure of conflict of interest

None.

Address correspondence to: Zhaogao Zhang, Department of Oral Surgery, Jiading District Teeth Disease Prevention and Treatment Institute, No. 79, North Street, Jiading District, Shanghai 201800, China. Tel: +86-021-59992073; Fax: +86-021-59992073; E-mail: dxh43AFH@163.com

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