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ORIGINAL RESEARCH

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Effects of Clearfil SE Bond 2 on restoring deciduous anterior teeth with ring caries and analysis of caries risk factors in children aged 3–8 years

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Abstract

To investigate the impact of various self-acid corrosion adhesives in restoring ring caries in anterior deciduous teeth and the influencing factors of childhood caries. This study retrospectively analyzed the repair effect of two kinds of restoration schemes on the annular caries of children's deciduous anterior teeth. According to the repair scheme, 54 children with caries were divided into two groups. The children with 3M single bond repair were set as the control group, and the children with Clearfil SE Bond 2 repair were set as the study group. The repair effect of 6 months and 12 months of treatment and the treatment satisfaction of children were compared. Additionally, 50 children with no oral abnormalities were included as a healthy control group to analyze dental caries risk factors comparatively. The retention of dental restorations, marginal adaptation to dentin, and dental pulp vitality scores in the study group were significantly lower than those in the control group at both 6 and 12 months post-treatment, with statistically significant differences ($p < 0.05$). Moreover, satisfaction levels in the study group notably exceeded those in the control group (92.59% *vs.* 70.37%). Fisher exact test yielded a p value of 0.041. Binary logistic regression analysis revealed that daily tooth brushing habits and parental supervision were protective against dental caries occurrence. Conversely, plaque, dental calculus, proficiency in tooth brushing techniques, and post-brushing bedtime snacking emerged as independent risk factors for dental caries ($p < 0.05$). Compared to the conventional self-etching dentin adhesive filling regimen, the novel blended adhesive and composite resin filling significantly enhanced dental caries restoration outcomes and increased children's satisfaction. Notably, this approach was well-received by both children and their families. Further proactive measures targeting children with identified risk factors are warranted to reduce the incidence of dental caries.

Keywords

Primary teeth; Dental caries; Binder; Restorative effect; Analysis of influencing factors

1. Introduction

Dental caries represents a prevalent oral ailment in children, potentially resulting in discomfort, swollen gums, diminished chewing capability, and, in advanced stages, may progress to pulp necrosis and gingivitis, and can impact the subsequent growth and development of permanent teeth [1, 2]. Early detection and treatment of annular caries in deciduous anterior teeth is very important. In clinical practice, composite resins are commonly used for restorative treatment post-removal of necrotic tissue in dental caries, often in conjunction with self-etching dentin adhesives. However, previous studies have demonstrated a susceptibility to filling defects or dislodgement during treatment with this regimen, potentially leading to complications such as pulpitis [3, 4]. Hence, there is a growing focus on investigating restorative therapies for ring caries in primary anterior teeth. Recent studies have indicated that the use of novel blended adhesives can effectively mitigate post-restorative complications [5, 6].

One of the most widely used in our hospital is Clearfil (SE Bond 2). This adhesive has a transparent color, which is very similar to the color of natural teeth, and almost no repair traces can be seen. Secondly, its wear resistance and strength are relatively good, which can ensure that the repaired teeth can withstand the daily chewing pressure, improve the bite force of patients, and make the repaired teeth more natural and comfortable [7]. 20 September marks the 33rd "National Love Teeth Day", with 2023 theme being "oral health, overall health", underscoring the importance of cultivating tooth-brushing habits from an early age to ensure lifelong health. Epidemiological studies focusing on oral health status are pivotal as they not only gather data on the prevalence and

severity of oral diseases across different populations but also provide data-driven support for planning health interventions, prevention strategies, and rehabilitation efforts. Additionally, they facilitate the evaluation of the efficacy of implemented health policies and strategies.

This study retrospectively analyzed the repair effect of colelifil, and analyzed the influencing factors of dental caries in children aged 3–8 years old in this region. Early intervention, increasing the popularization of oral health science, and providing oral health behavior guidance are of great significance for the prevention and control of children's oral health and reducing the occurrence of dental caries.

2. General data and methods

2.1 Study data

The clinical data of children with ring caries of primary anterior teeth treated in our hospital from March 2020 to August 2021 were retrospectively analyzed. Children who met the screening criteria were selected as the research objects. All children included in this study met the following screening criteria: age ranging from 3 to 8 years, meeting diagnostic criteria for dental caries [8], possessing normal dental pulp vitality with active root caries, root resorption not exceeding half of the root length, and deciduous tooth mobility not exceeding grade II. Additionally, informed consent was obtained from the children's families, who voluntarily signed consent forms, demonstrating high levels of adaptability. Conversely, exclusion criteria included children presenting with apical periodontitis or gingival inflammation accompanying dental diseases, as well as those exhibiting allergic reactions to the fillings or adhesives utilized in the study, and cases with markedly poor oral hygiene or parents displaying low adaptability and unwillingness to undergo follow-up. Ethical approval for the study was obtained from the hospital ethics committee. In this study, a total of 54 children with dental caries who met the research criteria were selected and divided into two groups according to the different repair schemes received. The children with 3M single bond repair were set as the control group, and those with SE bond repair were set as the study group, with 27 children in each group, Baseline data for both groups are presented in Table 1. An analysis of influencing factors was conducted as follows: the 54 children enrolled in the study constituted the dental caries group, while 50 healthy children who underwent oral examinations at the hospital during the same period were selected as the healthy control group to investigate influencing factors in both cohorts.

2.2 Study methods

All necessary precautions were thoroughly explained by a qualified physician before treatment to enhance the children's adaptability. The process of caries restoration comprised four sequential steps: decay removal, cavity preparation, gentle acid etching and filling. The specific operational procedure was as follows: Firstly, patients underwent oral cleaning. A low-speed drill was employed to delicately remove the decayed area, supplemented by a digging spoon to eliminate decay, with continuous irrigation until normal tooth color was restored. Simultaneously, children were instructed to expel liquid from the oral cavity promptly to alleviate discomfort. The entire process was performed carefully and with gentle handling. Subsequently, the cleaned cavities were disinfected using sterile alcohol cotton balls, dried with an air gun, and moisturized with absorbent cotton balls.

Patients in the control group received treatment with self-etching dentin adhesive (3M Single Bond Universal 8th generation universal adhesive, 41453, 5 mL, manufacturer: 3M Deutschland GmbH) following the same procedure described above. The adhesive was evenly applied to the children's cavities and then filled with composite resin (Dentsply TPH3) in layers after a 30-second light-curing interval. Each resin layer was cured to a depth of 2 mm. Light-curing was performed for 30 seconds after the application of each adhesive layer until the restoration was complete. Finally, the appearance of the corrected teeth was polished.

For the study group, a new mixed adhesive (Clearfil SE Bond 2 eighth generation adhesive 2892-CN, YZB/JAP 3592-2005, 6 mL sourced from Kuraray (Shanghai) Co., Ltd.) and composite resin (Dentsply TPH3) were applied following the same procedure as the control group. Both Clearfil SE Bond 2 and composite resin were used in the same manner as in the control group. Additionally, dietary recommendations were provided to ensure optimal oral hygiene for all enrolled children.

2.3 Outcome measures

2.3.1 Observation of therapeutic effects

All children were evaluated for restorative efficacy at 6 and 12 months post-treatment, including assessment of dental prosthesis retention, prosthesis marginal adaptation to dentin, and dental pulp vitality. The detailed scoring criteria are outlined in Table 2. Subsequently, satisfaction with the treatment among both children and their families was assessed through a questionnaire, covering aspects such as prosthesis appearance, masticatory function, cleanliness, and post-treatment eating habits. A scoring system ranging from 0 to 100 was utilized, with scores above 85 indicating very satisfactory outcomes, scores between 70 and 85 indicating basic satisfaction, and scores below 70 indicating dissatisfaction. Statistical analysis was conducted to evaluate overall satisfaction levels.

2.3.2 Children's oral health questionnaire

The oral health status of the children was assessed using the Children's Oral Health Questionnaire, supplemented by input from professional dentists. This questionnaire encompassed various aspects, including the age and gender of the child, frequency of consuming desserts or beverages, proficiency in tooth brushing techniques, daily habits, regularity of oral examinations, and knowledge of oral health care. Additionally, parental-related inquiries such as education level, primary caregivers for the children, and whether parents assisted with tooth brushing were included to align with the study objectives. All information was gathered using the questionnaire, which was distributed by professional nursing staff, and the contents and purposes were explained. The children were either supervised while completing the questionnaire on-site,

TABLE 1. Baseline data of 54 children.

Group	Case	Number of decayed teeth	Mean age (yr)	Male/Female	Number of decayed teeth		
					Primary central incisor	Deciduous lateral incisor	Deciduous canine
Control group	27	50	5.06 ± 0.82	11/16	22	15	13
Study group	27	52	5.16 ± 1.01	15/12	23	17	12
t/χ^2 value			0.405			0.148	
p value			0.687	0.414		0.929	

TABLE 2. Evaluation and scoring criteria.

Evaluation content	Score	Scoring criteria
(1) Dental prosthesis retention		
	0–3 point	The prosthesis appearance is complete with a smooth surface. The shape of the prosthesis and tooth were normally continuous.
	4–6 point	The surface of the prosthesis is rough and basically continuous with the tooth shape with no dentin exposed.
	7–9 point	Prosthesis surface breaks with shedding and dentin exposure.
(2) Marginal adaptation of restoration to dentin		
	0–3 point	The margins are tight without gaps, the probe cannot penetrate, and the prosthesis is not loose or falling off.
	4–6 point	There is a gap at the margin, the probe can be inserted and expose the dentin. The prosthesis shows signs of loosening but does not fall off.
	7–9 point	The dentin is exposed, and the prosthesis partially fell off.
(3) Dental pulp vitality		
	0–3 point	No spontaneous pain, hot or cold stabbing pain, normal tooth vitality.
	4–6 point	Presented spontaneous pain, slight hot or cold stabbing pain and abnormal pulp vitality.
	7–9 point	Pulp necrosis or no vitality.

or parents filled it out on their behalf. Any queries were addressed by professionals. Once completed, the questionnaire was collected immediately to ensure accuracy and prevent omissions, and the collected data were reviewed and analyzed by designated personnel.

2.4 Statistical methods

The raw data were summarized in tables and analyzed using SPSS version 23.0 (SPSS Co., Ltd., Chicago, IL, USA). Measurement data conforming to a normal distribution were presented as mean ± standard deviation. Comparative analysis was conducted using the independent sample t-test. Frequency data were expressed as n (%). Given the limited sample size, the Fisher exact test was employed for the satisfaction survey. In the analysis of factors influencing dental caries, continuous variables such as age were described using mean values, while categorical variables like gender and parental education were presented as counts (percentages). Group comparisons were performed using one-way analysis of variance and independent sample t-test. Additionally, binary logistic regression was utilized to analyze influencing factors. A significance level of $p < 0.05$ was considered statistically significant.

3. Results

3.1 Restorative efficacy in children

Comparative analysis following 6 months and 12 months of treatment showed that the restoration score, marginal adaptation score and pulp vitality score of the study group were significantly lower than those of the control group, with statistically significant differences observed ($p < 0.05$). Detailed results are presented in Table 3.

3.2 Comparison of children satisfaction

The satisfaction level within the study group was significantly higher than that of the control group (92.59% *vs.* 70.37%) ($p = 0.041$). The detailed results are shown in Table 4.

3.3 Comparison of general data between children with dental caries and healthy controls

Fifty-four children screened for the study were set as the caries group, and information was collected and compared with that of healthy control children (Table 5). No significant differences were observed in mean age, sex ratio, parental

TABLE 3. Restorative efficacy in children of both groups.

Group	Number of decayed teeth	Detection time	Score of dental prosthesis retention	Score of marginal adaptation	Score of dental pulp vitality
Control group	50	6 months after treatment	2.531 ± 0.916	2.851 ± 0.622	2.572 ± 0.652
		12 months after treatment	6.440 ± 1.123	6.910 ± 1.103	6.083 ± 1.371
Study group	52	6 months after treatment	1.341 ± 0.418	0.982 ± 0.262	1.223 ± 0.651
		12 months after treatment	3.140 ± 1.157	3.501 ± 1.263	3.180 ± 1.012
t1/*p* value			8.498/<0.001	19.871/<0.001	10.485/<0.001
t2/*p* value			14.581/<0.001	14.559/<0.001	12.242/<0.001

Note: t1/p value and t2/p value represent the score comparison after 6 months and 12 months of treatment, respectively.

TABLE 4. Comparison of children satisfaction (n (%)).

Group	Case	Very satisfied	Basically satisfied	Dissatisfied	Overall satisfaction (%)
Control group	27	8 (29.63)	11 (40.74)	8 (29.63)	70.37
Study group	27	16 (59.25)	9 (33.33)	2 (7.41)	92.59
p value					0.041

education, primary caregivers, residence, frequency of consuming desserts or beverages, regularity of oral cavity examinations, acquisition of oral health knowledge, and post-meal gargling habits between the two groups ($p > 0.05$). However, significant differences were noted between the groups regarding daily tooth brushing habits, parental supervision (assistance), plaque accumulation, presence of dental calculus, proficiency in tooth brushing techniques, and post-brushing bedtime snacking habits ($p < 0.05$).

3.4 Binary logic regression analysis for dental caries

The variables showing differences in Table 6 were selected and subjected to binary logistic regression analysis as independent variables. According to the table, the statistical values of each factor in the table are statistically significant, in addition the results indicated that daily tooth brushing habits and parental supervision (assistance) acted as protective factors against the incidence of dental caries. Conversely, dental plaque, dental calculus, proficiency in tooth brushing techniques, and post-brushing bedtime snacking emerged as independent risk factors for dental caries incidence ($p < 0.05$).

4. Discussion

Oral disease is a non-communicable disease that is often overlooked. In recent years, with the improvement of people's living standards, more and more people have started to lay more emphasis on oral health, with special focus has been placed on addressing oral health issues in children, a vulnerable demographic [9]. According to data from the National Oral Health Epidemiological Survey, the average number of dental caries in Chinese children aged 3–5 years ranges from 2 to 4, with a staggering 71.9% incidence rate among 5-year-olds, showing early onset and high-risk characteristics with a concerning upward trend [10–13]. Triggers of dental caries in children primarily include the following factors: inadequate and careless tooth brushing during the deciduous stage, failure to promptly remove dental plaque, leading to acid production by bacteria, as well as excessive consumption of sugary foods. Additionally, habits such as nursing to sleep during infancy or drinking milk before bedtime without subsequent gargling and tooth brushing can contribute to dental caries. Furthermore, beyond these acquired factors, the occurrence of dental caries in children is also influenced by inherent factors such as constitution, tooth structure and saliva composition. To safeguard children's oral health, parents should ensure regular dental examinations to promptly identify and intervene in any issues, thereby preventing complications such as pulpitis, apicitis and others [14–17]. The treatment of dental caries in children primarily revolves around two principles: halting the progression of decayed teeth and restoring their shape and function. However, in attempting to prevent the advancement of dental caries, it is important to remove all carious tissues and select appropriate filling materials [18]. Additionally, as dental caries in children can affect not only normal dental function but also aesthetics and speech, selecting the optimal filling program is of paramount importance [19, 20]. Relevant studies have shown a high prevalence of dental caries among children in China, with its incidence linked to various factors, including behavioral, cultural, and socioeconomic aspects such as family background, oral hygiene practices, and dietary habits. These findings underscore the importance of elucidating these factors for disease control and prevention purposes [21–23]. Many parents may not be aware that dental caries initially affects

TABLE 5. Comparison of general data between children with dental caries and healthy controls.

General data	Dental caries group (n = 54)	Healthy control group (n = 50)	*t*/*F*	*p*
Mean age	5.112 ± 0.904	5.023 ± 1.059	0.473	0.637
Sex				
Male	26	29	1.002	0.319
Female	28	21		
Parent education				
Junior high school and below	23	14		
Senior high school	21	20	3.491	0.065
Bachelor degree or above	10	16		
Daily brushing habits				
Regular	19	28	4.657	0.033
Irregular	35	22		
Daily care staff				
Parents	30	26	0.130	0.719
Not parents	24	24		
Parental supervision (assistance) tooth brushing				
Yes	21	38	16.613	<0.001
No	33	12		
Plaque				
Yes	38	20	10.501	0.002
No	16	30		
Dental calculus				
Yes	40	18	17.536	<0.001
No	14	32		
Residence				
City	30	33	1.176	0.281
Rural	24	17		
Frequency of eating desserts or beverages				
Occasional	22	28	2.432	0.122
Frequent	32	22		
Mastery of tooth brushing				
Not understood	28	12		
Understand less	14	20	7.111	0.009
Fully mastered	12	18		
Periodic oral examination				
Never	25	16		
Occasional	14	23	0.297	0.587
Frequent	15	11		
Oral health knowledge acquisition				
TV/Short Video	13	10		
Family	18	16		
School	6	3	1.343	0.249
Oral health care provider	5	6		
Community Health Activities	5	5		
None above	7	10		
Gargle after meal				
Never	21	15		
Occasional	17	14	1.666	0.200
Frequent	16	21		
Eating after tooth brushing before bedtime				
Yes	38	17	13.733	<0.001
No	16	33		

TV: Television.

TABLE 6. Binary logic regression analysis.

Factors	β	SE	wald	sig	95% Confidence interval for EXP (B)
Daily brushing habits	−0.852	0.403	4.471	0.034	0.427 (0.194–0.940)
Parental supervision (assistance) tooth brushing	−1.605	0.433	13.728	<0.001	0.201 (0.086–0.470)
Plaque	1.270	0.415	9.376	0.002	3.562 (1.580–8.034)
Dental calculus	1.625	0.428	14.415	<0.001	5.079 (2.195–11.754)
Mastery of tooth brushing	0.648	0.253	6.542	0.011	1.912 (1.164–3.141)
Eating after tooth brushing before bedtime	1.440	0.419	11.813	0.001	4.222 (1.857–9.600)

β: beta-coefficient; SE: standard error; wald: Wald test; sig: significance; EXP: exponent.

the inner structure of teeth. By the time visible decay is noticed, significant damage to the tooth structure may have already occurred. Therefore, while dental caries in children may be common, it should not be underestimated [24]. Parents should prioritize the prevention and treatment of dental caries, emphasizing the importance of maintaining good oral health from an early age.

Currently, self-etching adhesives integrated with composite resins are widely used in clinical practice, representing a physical mechanical adhesive approach. Self-etching adhesives use irrigation-free acidic monomers to interact with tooth tissue, reducing operational sensitivity and treatment duration [25, 26]. However, extensive clinical research has revealed that the utilization of self-etching adhesive is less effective compared to full etching methods. Strong etching self-etching adhesives typically exhibit a pH value of 1.0 or lower, inducing a certain degree of demineralization. While the etching pattern produced on the enamel layer resembles that of phosphoric acid treatment following full etching, it is shallower in depth. Therefore, the bonding efficiency on the enamel layer is diminished, thereby reducing the degree of bonding between dentin and the restoration. Moreover, this process may stimulate the dental pulp to a certain extent, potentially leading to pulpitis [27, 28]. New mixed adhesives, such as Clearfil SE Bond, have garnered attention in clinical research. Clearfil SE Bond offers advantages, including realistic coloration, with a dual-color system that closely mimics natural tooth color, thus enhancing restoration aesthetics. Additionally, its high abrasion resistance, attributed to its 85.5% inorganic filler content, ensures durability. Furthermore, this material exhibits notable strength and toughness, enabling effective coping with occlusal forces regardless of caries location [29]. Previous studies have also demonstrated that Clearfil SE Bond does not induce oral sensitivity and provides a high level of comfort [30].

In the present study, two distinct filling regimens were compared, revealing that the new mixed adhesive and composite resin protocols yielded superior outcomes in restoring dental caries in children. This efficacy was evident in the scores of prosthesis retention, marginal adaptation, and pulp vitality within the study group at 6 and 12 months post-treatment, demonstrating significantly higher values compared to those observed in the control group during the same period. Clearfil SE Bond 2, similar in composition to 3M ESPE (Evidence-based Specialty of Prosthodontics and Esthetic Dentistry), contains 10 methacryloyloxydecyl dihydrogen phosphate (MDP) as a functional monomer. Despite the shared components between the materials, variations in the quantities and proportions of water, solvent, MDP, and dimethacrylate resins in the adhesives may impact viscosity and wettability, thereby influencing resin monomer penetration into decalcified dentin during self-etching adhesive application. The reduced acid etching intensity of self-etching adhesives may compromise marginal adaptation between the restoration and dentin. However, the new mixed adhesive not only compensates for adhesive adaptation but also enhances restoration retention. The satisfaction survey results from both children and parents post-treatment reveal that the new mixed adhesive integrated with composite resin filling significantly improves children's satisfaction and is more readily endorsed by parents. We believe that these might be attributed to the enhanced adaptation and retention capabilities of the new mixed adhesive.

The results of the analysis of the influencing factors revealed that daily tooth brushing habits and parental supervision (assistance) serve as protective factors against the occurrence of dental caries. Conversely, plaque accumulation, the presence of dental calculus, inadequate mastery of tooth-brushing techniques, and post-brushing bedtime snacking emerged as independent risk factors. These findings highlight the importance of parental supervision in fostering daily tooth brushing habits, which contributes to reducing the risk of dental caries. For children with dental plaque and calculus, particular attention should be paid to those who struggle with tooth-brushing techniques and engage in bedtime snacking after brushing. It is imperative for such individuals to undergo regular oral examinations to promptly identify and address any issues, thereby preventing potential complications such as misalignment of permanent teeth and irregular tooth positioning. Failure to intervene in a timely manner can lead to compromised eating and chewing function, subsequently impacting overall growth and development.

5. Conclusions

In conclusion, the Clearfil SE Bond 2 and composite resin filling protocol demonstrate long-term effectiveness in restoring annular dental caries in deciduous anterior teeth and enhancing children's satisfaction, thus representing a safe and efficient restoration approach. Alongside selecting appropriate treatment modalities, parents should prioritize enhancing oral health awareness and encouraging children to cultivate good oral hygiene habits. It is imperative to intensify efforts in

promoting oral health awareness, particularly emphasizing the importance of maintaining clean tooth surfaces, especially for children with suboptimal oral hygiene characterized by increased dental plaque or calculus. This emphasis should commence with the children themselves, and regular oral examinations should be encouraged to facilitate early detection and intervention for any emerging issues. The limitation of this study is that the study sample is limited, and the study observation time is limited. Even if the resin is filled with multiple light curing filling to reduce its shrinkage, it will still have shrinkage performance, and will turn yellow after a long time. In the future, this study will expand the number of study samples, in-depth study content, and extend the follow-up time to observe the long-term repair effect of the repair agent. The analysis of influencing factors in this study uses a general influencing factor survey form, so it can only reflect some characteristics of children in this region, and has not found some new influencing factors. In order to further improve the research of influencing factors, the survey content will be further supplemented and improved in future research.

AVAILABILITY OF DATA AND MATERIALS

All data generated or analyzed during this study are included in this published article. The datasets used and/or analyzed during the present study are available from the corresponding author on reasonable request.

AUTHOR CONTRIBUTIONS

JX—designed the research study. QL—performed the research. QQZW and XYL—analyzed the data. YJY and MMC—wrote the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval was obtained from the Ethics Committee of Dongfeng Stomatological Hospital (Approval No. 2020-034). All families of enrolled children provided written informed consent or voluntarily signed consent forms before participating.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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