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Silver-Modified Atraumatic Restorative Treatment (SMART) in Managing Carious Primary Molars: 1-Year Clinical Results

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ABSTRACT

Purpose: Silver-modified atraumatic restorative treatment (SMART) is a minimally invasive method that can be utilized for the management of early childhood caries. This study aimed to assess the 12-month clinical success of the SMART technique in the management of carious primary molars.

Methods: The analysis (Modified-United States Public Health Service Criteria) was performed on the 3rd, 6th and 12th months clinical records of 53 teeth of uncooperative patients aged between 2-6 years treated with the SMART technique. The included teeth with no spontaneous pain and sensitivity to percussion-palpation, were divided into groups by location (mandibular-maxillary) and carious cavities (occlusal, mesio/disto-occlusal, mesio-occlusal-distal). Fisher Exact Chi-Square test was used to determine the relation between the groups and p-value < 0.05 was accepted as statistically significant.

Results: The success rate of SMART for retention, marginal discoloration, and secondary caries in the mandible (84.8%), was higher than the values detected in the maxilla (38.5%) and teeth with occlusal caries were significantly more successful at 12-month assessments (p= 0.038). Mandibular cases and occlusal cavities revealed better results in marginal adaptation assessments (78.8%, and 88.9%, respectively).

Conclusions: This paper has the novelty of being the first study assessing the effect of the type of carious cavity and the tooth location in the clinical success of SMART technique. Accordingly, SMART may conclude to be an alternative for the treatment of carious teeth of uncooperative children at least for a period until the child becomes mature to comply with the advanced treatment procedures.

Key-words: *Dental atraumatic restorative treatment, fluoride treatment, preventive dentistry, silver diamine fluoride.*

INTRODUCTION

Despite the recent advances in paediatric preventive approaches, dental caries still presents to be the world's most prevalent chronic health problem seen in childhood.[1] Early childhood caries (ECC) is the term that defines at least one carious lesion seen in children under the age of 6 and composes a considerable part of daily paediatric treatment procedures. The recent prevalence of the disease is reported to be 48% according to a meta-analysis.[1,2] ECC can lead to serious health and financial problems. Children may have nutrition deficiencies due to the chewing problems related to tooth ache. Several dental sessions may cause missed school days for the children and working days-hours for the parents with educational and financial consequences. Considering the early age of ECC-affected children, the compliance

of the patient is the most challenging part of the treatment procedure and the need for general anaesthesia, dental sedation may also cause additional health problems and economic burdens both for the families and dental professionals.[3]

The modern approaches that aim to preserve the natural tooth structure led to recent dental practices into the pathway of minimal-invasive treatment (MIT) strategies. Being one of the most known MIT approaches, the atraumatic restorative treatment (ART) also gained recent popularity, especially in the treatment of ECC-affected children with inadequate cooperation to treatment.[4,5] The effect of COVID-19 pandemic restrictions and the cautions on avoiding aerosol-releasing rotary systems have also highlighted the advantages of ART systems.[6,7] Another popular approach in MIT strategies is the Silver Diamine Fluoride (SDF) application. SDF acts by releasing silver and fluoride ions following the application to the caries-affected tissue, therefore involved in the formation of fluorohydroxyapatite and increasing the mineral density and tissue hardness.[8-10] Despite the blackening effect of silver ions, SDF applications have numerous advantages.[11,12] This technique does not require anaesthesia, or caries excavation by rotary instruments and therefore can be described as a pain-free method that gained recent popularity, especially in the treatment of young children.[4,13] Additionally, the consequent applications of ART with SDF and finishing up the restoration with conventional or injectable glass ionomer cement (GIC) placement, literally the silver-modified atraumatic restorative treatment (SMART), come to the fore as a method that composes all the advantages of the listed MIT approaches. SMART does not require anaesthesia injection or rotary instrumentations. This technique leads to easy treatment of uncooperative young children and adults with dental phobia and even can be preferable in conditions with no access to rotary systems or in the situations with restrictions for aerosol releasing systems. The term ''SMART'' includes both carious removing, dentine disinfection and restoration stages with the favourable effects of SDF application and the ease of GIC placement. Although injectable GIC is the choice of treatment in these therapies, conventional glass ionomer cement applications can also be considered as an alternative. This method with caries arresting and fluoride-releasing features has positive effects in the treatment of young children in need of dental treatment and can be a considerable choice for the treatment of ECC-affected uncooperative patients.[4]

Systematic reviews reported the success of SDF in caries arresting. However, the literature review has also revealed a limited number of studies evaluating the effectiveness of SDF application and SMART technique in the treatment of ECC-affected cases.[14] Furthermore, no study was detected assessing the effect of the type of carious cavity and tooth location in the clinical success of SMART technique with conventional GIC in the management of ECC-affected cases. In light of the aforementioned data, this retrospective study aimed to evaluate the effects of tooth location and type of carious cavity on the clinical success of the SMART technique in ECC-affected cases. The null hypothesis of the study was that tooth location and type of carious cavity would have no effect on the clinical success of the SMART technique.

MATERIAL AND METHODS

Ethical consideration

University of Health Science Scientific Research Ethical Committee has approved the study protocol (2023-27, 17/1/2023) and the study was conducted in line with the Helsinki Declaration with all amendments and revisions. The analyses of the records were conducted between March-May 2023.

Sample Size Determination

The sample size of the study was determined with the aid of G*Power software (ver 3.1.9.4). The analysis was conducted in accordance with the previous studies,[15,16] and accordingly, to achieve % 80 power (Z=0.842) with an effect size of 0.39, and alpha significance level of 5% (0.05) the required sample size was determined to be at least 52. Accordingly, the

records of 53 teeth of 43 patients aged between 2-6 years decided to be included in the study.

Case Selection

The study was conducted in Ankara city representing the large parts of the country considering being a capital city and having a variety of people from different parts of the country. Accordingly, the study population can be described as a good sample of Turkey country and the oral hygiene of the treated group can be described as inadequate considering the mean decayed, missed, filled teeth (dmft) values (3.64±4.04, 5 years-old population) of the country in accordance with the recent general oral health assessment conducted by Ministry of Health, Republic of Turkey.[17] The primary molars of the uncooperative patients aged between 2-6 years and with no systemic diseases (ASA I)[18] treated with SMART technique in the clinics of University of Health Science Faculty of Dental Medicine between the dates of December 2020 - December 2021, by a single paediatric dentistry practitioner considered to be included in the study. The analyses of the clinical records were conducted between the dates of March-May 2023. The clinical and radiological examination criteria prior to treatments were as follows: Dentinal caries at any degree (initial, moderate, or deep), no spontaneous pain that can be related to irreversible pulpitis, no palpation and percussion sensitivity, no physiological and pathological mobility, no periapical/furcal radiolucency, presence of lamina dura, absence of pathological root resorption. In the cases with deep dentinal caries, the presence and the continuity of the dentine band between the cavity floor and pulp chamber was an additional criterion of the cases to be included in the study. The dmft values of each child were also assessed in accordance with the World Health Organization (WHO) evaluation criteria and recorded. The treated group comprised of uncooperative children that at least have had one previous dental visit with the same operator in which the cooperation of the child to the conventional treatment methods which involves anaesthesia injection, and the use of rotary instruments were decided to be inadequate. The patients and their legal representatives were informed regarding the possible blackening effect of SDF and the ones who have concern on this issue were treated with other minimally invasive treatment techniques.

Clinical Procedure of SMART Technique

The SMART technique was recruited in line with the following clinical protocols: Vitality assessment with cold test (Endo-frost), cotton pellet isolation, selective caries removing of necrotic and demineralized dentine with sharpened excavators and leaving the soft dentine nearest to the pulp tissue in the cases with deep dentinal caries, removing the soft dentine and leaving the leathery dentine in the cases with moderate dentinal caries and the total excavation of the carious tissue in the initial caries. The cavity walls were excavated till the hard dentine was achieved in all cases in according with the protocols of selective caries removing.[19] Following the caries removal, the cavity was cleaned with physiological saline and dried with air spray. The lips and the gingiva were also isolated with petroleum jelly and 38% SDF (Kids-e-dental LLP, Mumbai, India) was applied on the cavity with micro brush in accordance with the recommendations of the manufacturers (1 drop/ 10 kg per visit), left for 1-3 minutes and cleaned with cotton tips. The cavities were not filled in this first session and the patients were recalled a week after SDF application for GIC placement. In the second visit, the cotton pellet isolation was achieved, the cavity was cleaned with saline solution, dried and the restoration of the cavity was performed with conventional GIC (R&D Series Nova Glass F, Imicryl, Konya, Turkiye) placement. GIC was gently adapted under finger pressure. The excess material was quickly removed, and the occlusion was checked and adjusted (if necessary) after removing the cotton pellets. The surface of the glass ionomer restoration was covered by Riva Coat (SDI, Victoria, Australia). The reason for postponing the restoration was to avoid the possible discoloration effect of silver ions on the glass ionomer restoration.[20] A representative image of the SMART technique can be seen in Figure 1. The patients were recalled at 3,6 and 12 months and following clinical and radiographical examinations, intraoral digital images were obtained from all patients that attempts to follow-up sessions. The listed clinical treatment protocols were all performed with one single operator with a clinical experience of 3 years in paediatric dentistry and the follow-up sessions that includes the obtaining of intra-oral digital imaging were also performed with the same operator.

Digital Imaging Techniques

Digital images were obtained following GIC placement (initial) and at control appointments (3rd,6th, 12th months). All clinical records were obtained by the same device, EOS 1100D (Canon, Tokyo, Japan), with a ring flash and 100-mm macro lens (Canon, Tokyo, Japan) at a standardized 1:1.2 magnification and manual parameters (ISO 200, T:1/160, F:22). The digital images were obtained by the same paediatric dentistry practitioner who performed the clinical procedure of SMART technique.

At each recall period, the retention of SMART sealants was evaluated clinically by using a calibrated right-angled dental explorer with a tip thickness of 250 µm after removing the plaque and debris with a gauze and air-drying.

Another paediatric dentist searched the digital images of the SMART-treated patients and the records of the patients that treated with SMART technique following the previously mentioned clinical procedure were examined. The digital images of the patients that have 3rd, 6th and 12th months' follow-up records were included in the study. The images with poor quality (poor contrast, lowlights intensity, and loss of detail in recorded image) or the cases with absent recordings at least on one follow-up period were excluded from the study. The analyses of the digital image records were performed between March-May 2023.

Quality Control

The Modified United States Public Health Service (USPHS) Criteria, the most accepted method for assessing dental restorations' survival by means of retention, marginal adaptation, marginal discoloration, and secondary caries development, was performed for the analyses.[21] Since this was a retrospective study, all the evaluations were made on the recorded images of the treated teeth including the initial and follow-up images recorded in 3rd, 6th and 12th months.

Each image was analysed by two different paediatric dentists who have not involved in the previous treatment and follow-up sessions and with an experience of 3 years. The appropriate score for each examination was noted. Another paediatric dentist with an experience of 10 years also analysed the images and the given scores were checked. The disagreements were studied by the two specialists and a consensus was provided on the scoring of each image. The Modified USPHS Criteria were scored with the terms "Alpha", "Bravo" and "Charlie". The value "Alpha" is the best level clinically. The value "Bravo" is considered clinically "successful" and does not require any intervention, although it may be accompanied by some deformations. "Charlie" is considered clinically unsuccessful and indicates a situation where the restoration needs to be replaced or repaired. The Modified USPHS Criteria[22, 23] were scored as shown in Table 1**.**

The teeth with Alpha and Bravo values were classified as successful while the teeth with the value Charlie were considered as unsuccessful cases.[24] The treated teeth were divided into groups according to tooth location (Mandibular-Maxillary) and the type of carious cavity (occlusal cavity: Group-O; mesio/disto occlusal cavity: Group-MO/DO; mesio-occlusal-distal cavity: Group-MOD). The teeth with Charlie score for any of the criteria were recorded as unsuccessful and excluded from the study and the examinations were held on the images of the remained teeth.

Statistical Analysis

Statistical methods were used to examine whether the treatment success rates differed between tooth location and type of carious cavity groups. Statistical analysis was obtained with the aid of SPSS version 20.0 software (Statistical Package for the Social Sciences for Windows 13.0, IBM Inc., Chicago, IL, USA). Demographical descriptions of the patients were given as frequency and percentages. Fisher Exact Chi-Square test was used to determine the relation between the groups. Intraclass correlation coefficient (ICC) was calculated to assess the intra- and inter-examiner reliability. A p-value< 0.05 was used for statistical significance.

RESULTS

The 12th month follow-up records of 43 patients (44.2% - females and 55.8% - males) and 53 teeth were analysed in the study. Statistical methods were used to examine whether the success rate of the treatment differed regarding tooth location and type of carious cavity. In the statistical analysis, demographic

characteristics were presented as Frequency (n) and Percentage (%).

Approximately 60% of the participants were among the age group of 4 and 5. The tooth number 85 was the most frequently encountered (15 teeth, 28.3%). The total number of treated mandibular teeth were 36 (67.9%), while the same values for maxillary teeth were 17 (32.1%). Group-O had the highest frequency with 20 teeth (37.7%). Additionally, the frequencies for Group-MO/DO and Group-MOD were 19 (35.8%) and 14 (26.4%), respectively (Table 2). The mean (±SD) dmft of all patients was 4.25±3.56. The frequencies of Alpha, Bravo, Charlie values for each parameter (retention, marginal discoloration, secondary caries and marginal adaptation) can be seen in Table 3.

ICC was at least 0.964 with a high inter-examiner reliability for Modified USPHS criteria. Chi-square tests for retention, marginal discoloration, and secondary caries for these three variables yielded identical results. Therefore, these results are presented together as the outcomes of the same parameter. At 12th month analysis, a statistically significant relation between the treatment success and tooth location (p-value<0.05) was detected. Accordingly, the success rate of retention, marginal discoloration, and secondary caries in the mandible (84.8%) was higher than the values detected for the same parameters in the maxilla (38.5%) (p-value= 0.003). In accordance with the values for marginal adaptation regarding tooth location, a statistical relation was detected between the values of 12-month observations (p-value= 0.014) and the success rate for mandible revealed higher results (78.8%) compared to the results detected in maxilla (38.5%) (Table 4).

Considering the identical results, the values for the relation of retention, marginal discoloration, and secondary caries and the type of carious cavity were also shown together as the outcomes of the same parameter. Accordingly, no statistically significant relation was detected among the compared parameters in any of the observational periods (p-value>0.05). However, a statistically significant relation was detected regarding marginal adaptation in the assessments of 12th month. Group-O revealed a higher success rate (88.9%) compared to the values of Group-MO/DO (56.3%) and Group-MOD (50%) (p-value= 0.038) (Table 5) (Figure 2).

Table 1. The modified USPHS rating criteria applied for the assessments

	Assessment	Alpha	Bravo	Charlie
Marginal Adaptation	Visual inspection¶	Continuity at the margin	Slight discontinuity at the margin	Marginal defects requiring replacement
Retention	Visual inspection	Restoration present	Partial loss of restoration-clinically acceptable	Clinically unacceptable partial-total loss of restoration
Marginal Discoloration	Visual inspection	No discoloration	Superficial discoloration	Extensive discoloration of the margins directed through the pulp
Seconder Caries	Visual inspection	Caries absent	-	Caries present

¶ Probing was also recommended in marginal adaptation assessments; however, this stage was not performed since the analyses were made on recorded images.

Table 2. The frequencies and ratio of the demographic characteristics of the participants, tooth number, location and type of carious cavity

Parameter	Category	Frequency (n)	%
Gender	Female	19	44.2
	Male	24	55.8
Age	2	4	9.3
	3	8	18.6
	4	14	32.6
	5	14	32.6
	6	3	6.9
Total Cases		**43**	**100**
Tooth Number	54	1	1.9
	55	4	7.5
	64	6	11.3
	65	6	11.3
	74	7	13.2
	75	6	11.3
	84	8	15.1
	85	15	28.3
Tooth Location	Mandibular	36	67.9
	Maxillary	17	32.1
Type of Carious Cavity	O†	20	37.7
	MO/DO‡	19	35.8
	MOD§	14	26.4
Total Teeth		**53**	**100**

†: Occlusal, ‡: Mesio/Disto-Occlusal, §: Mesio-Occlusal-Distal

Table 3. The frequencies of Alpha, Bravo, Charlie values for each parameter (retention, marginal discoloration, secondary caries and marginal adaptation)

	Score	Follow-up														
		3 months					6 months					12 months				
		n (%)					n (%)					n (%)				
		Mand[a]	Max[b]	O[†]	MO/DO[‡]	MOD[§]	Mand[a]	Max[b]	O[†]	MO/DO[‡]	MOD[§]	Mand[a]	Max[b]	O[†]	MO/DO[‡]	MOD[§]
Marginal Adaptation	A	31 (58.5)	11 (20.7)	18 (34.0)	13 (24.5)	11 (20.7)	19 (37.3)	2 (3.9)	16 (31.4)	4 (7.8)	1 (2.0)	15 (32.6)	2 (4.4)	15 (32.6)	2 (4.4)	-
	B	5 (9.4)	4 (7.6)	2 (3.8)	5 (9.4)	2 (3.8)	14 (27.4)	11 (21.6)	2 (3.9)	12 (23.5)	11 (21.6)	11 (23.9)	3 (6.5)	1 (2.2)	7 (15.2)	6 (13.0)
	C	-	2 (3.8)	-	1 (1.9)	1 (1.9)	3 (5.9)	2 (3.9)	2 (3.9)	2 (3.9)	1 (2.0)	7 (15.2)	8 (17.4)	2 (4.4)	7 (15.2)	6 (13.0)
Retention	A	34 (64.1)	17 (32.1)	20 (37.7)	18 (34.0)	13 (24.5)	23 (45.1)	11 (21.6)	13 (25.5)	11 (21.6)	10 (19.6)	17 (37.0)	10 (21.7)	11 (23.9)	7 (15.2)	9 (19.6)
	B	-	-	-	-	-	8 (15.7)	4 (7.8)	5 (9.8)	5 (9.8)	2 (3.9)	4 (8.7)	2 (4.4)	1 (2.2)	3 (6.5)	2 (4.4)
	C	2 (3.8)	-	-	1 (1.9)	1 (1.9)	3 (5.9)	2 (3.9)	2 (3.9)	2 (3.9)	1 (2.0)	10 (21.7)	3 (6.5)	6 (13.0)	6 (13.0)	1 (2.2)
Marginal Discoloration	A	-	-	-	-	-	31 (60.8)	-	-	-	-	-	-	-	-	-
	B	34 (64.1)	17 (32.1)	20 (37.7)	18 (34.0)	13 (24.5)	-	15 (29.4)	18 (35.3)	16 (31.4)	12 (23.5)	21 (45.7)	12 (26.1)	12 (26.1)	10 (21.7)	11 (23.9)
	C	2	-	-	1 (1.9)	1 (1.9)	3 (5.9)	2 (3.9)	2 (3.9)	2 (3.9)	1 (2.0)	10 (21.7)	3 (6.5)	6 (13.0)	6 (13.0)	1 (2.2)
Secondary Caries	A	34 (64.1)	17 (32.1)	20 (37.7)	18 (34.0)	13 (24.5)	31 (60.8)	15 (29.4)	18 (35.3)	16 (31.4)	12 (23.5)	21 (45.7)	12 (26.1)	12 (26.1)	10 (21.7)	11 (23.9)
	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C	2 (3.8)	-	-	1 (1.9)	1 (1.9)	3 (5.9)	2 (3.9)	2 (3.9)	2 (3.9)	1 (2.0)	10 (21.7)	3 (6.5)	6 (13.0)	6 (13.0)	1 (2.2)
Total (n)		53					51					46				

a: Mandibular, b: Maxillary, †: Occlusal, ‡: Mesio/Disto-Occlusal, §: Mesio-Occlusal-Distal, A: Alpha, B: Bravo, C: Charlie

Table 4. Chi-square test results for "marginal adaptation, retention, marginal discoloration, and secondary caries success-tooth location"

		Marginal Adaptation						Retention, Marginal Discoloration, Secondary Caries					
	Treatment	**Month 3**		**Month 6**		**Month 12**		**Month 3**		**Month 6**		**Month 12**	
		n	**%**	**n**	**%**	**n**	**%**	n	%	n	%	n	%
General	Successful	51	96.2	46	90.2	31	67.4	51	96.2	46	90.2	33	71.7
	Unsuccessful	2	3.8	5	9.8	15	32.6	2	3.8	5	9.8	13	28.3
Mandibular	Successful	36	100	33	91.7	26	**78.8**	36	100	33	91.7	28	**84.8**
	Unsuccessful	0	0	3	8.3	7	21.2	0	0	3	8.3	5	15.2
Maxillary	Successful	15	88.2	13	86.7	5	**38.5**	15	88.2	13	86.7	5	**38.5**
	Unsuccessful	2	11.8	2	13.3	8	61.5	2	11.8	2	13.3	8	61.5
***p*-value**		.099		.624		**.014***		.099		.624		**.003***	

Successful: Alpha, Bravo; Unsuccessful: Charlie,* Significant at p-value< 0.05

Table 5. Chi-square test results for "marginal adaptation, retention, marginal discoloration, and secondary caries success-tooth type of carious cavity"

		Marginal Adaptation						Retention, Marginal Discoloration, Secondary Caries					
	Treatment	**Month 3**		**Month 6**		**Month 12**		**Month 3**		**Month 6**		**Month 12**	
		N	**%**	**n**	**%**	**n**	**%**	n	%	n	%	n	%
General	Successful	51	96.2	46	90.2	31	**67.4**	51	96.2	46	90.2	33	71.7
	Unsuccessful	2	3.8	5	9.8	15	32.6	2	3.8	5	9.8	13	28.3
O†	Successful	20	100	18	90	16	**88.9**	20	100	18	90	16	88.9
	Unsuccessful	0	0	2	10	2	11.1	0	0	2	10	2	11.1
MO/DO‡	Successful	18	94.7	16	88.9	9	**56.3**	18	94.7	16	88.9	10	62.5
	Unsuccessful	1	5.3	2	11.1	7	43.8	1	5.3	2	11.1	6	37.5
MOD§	Successful	13	92.9	12	92.3	6	**50**	13	92.9	12	92.3	8	66.7
	Unsuccessful	1	7.1	1	7.7	6	50	1	7.1	1	7.7	4	33.3
***p*-value**		.521		1.00		**.038***		.521		1.00		.079	

Successful: Alpha, Bravo; Unsuccessful: Charlie, * Significant at p-value< 0.05, †: Occlusal**,** ‡: Mesio/Disto-Occlusal**,** §: Mesio-Occlusal-Distal

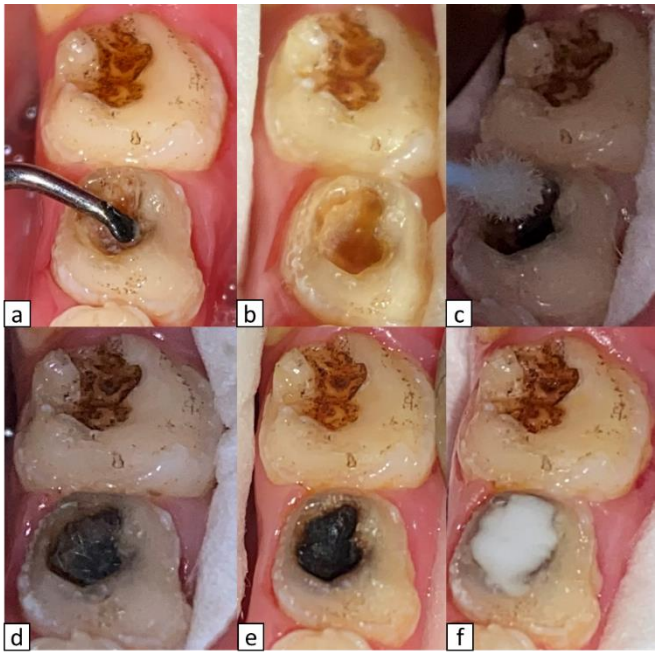

Figure 1. Clinical application phases of the SMART procedure applied to the affected mandibular primary first molar tooth with a cavity design of Group-O. a-b-c; after removal of soft dentin caries with an excavator, SDF solution is applied with an applicator. d; clinical image of the cavity after application of SDF. e; clinical image of a hardened caries lesion 1 week after SDF application. f; GIC application 1 week after SDF application.

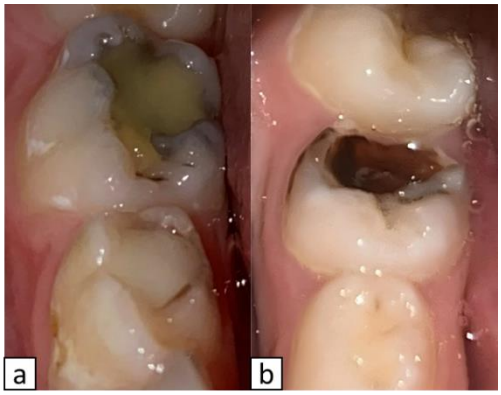

Figure 2. Case-1, a; image of the clinical success of tooth 85 at the end of 12 months. Case-2, b; clinical failure image of tooth 85 at the end of 12 months.

DISCUSSION

The results of the current retrospective study, wherein the clinical survival of the ECC-affected teeth treated with the SMART technique was assessed, revealed that although the clinical success was high in the records of the first 6th month follow-ups, this success was not preserved in the following period. However, the records suggested an acceptable clinical survival in the 12th month follow-ups. The clinical

outcomes of Group-O and mandibular restorations revealed better results statistically compared to Group-MO/DO and maxillary restorations.

The patients with ECC tend to be non-cooperative due to the young age of the affected population. ART with the following application of SDF can be considered as a logical alternative in the treatment of non-cooperative dental patients. Subsequent use of GIC is also recommended due to the self-adhesive performance of the material and the consequent fluoride-releasing effect.[25] The literature review has revealed limited information on the clinical survival of the cases treated with the SMART technique.[23] Accordingly, this retrospective study aimed to assess the restoration survival of SMART-applied cases performed in our clinics, especially during the period of the pandemic.

In the current study, patients' clinical records and anamnesis were reviewed, and the recorded images of patients with SMART-applied primary molars were examined in detail by two specialized dentists. The images were assessed using an internationally recognized tool named Modified USPHS Criteria. This tool is commonly used in previous studies to evaluate features of restorations like colour differences, secondary caries, adhesion problems, and marginal integrity. Various treatment approaches can be considered in the stage of removing the carious tissue in primary dentition. One recent approach involves selectively removing soft dentin to avoid damaging the pulp. In this approach, the affected dentin is left in the neighbourhood of the pulp, considering the depth of the lesion to avoid a possible pulpal perforation. In accordance with this statement and considering the effect of the Covid-19 pandemic, a selective caries removal technique was utilized by excavator instruments in the analysed cases of the current study. Subsequently, following the application of SDF the cavities were filled with conventional GIC.[26]

In the literature, various concentrations of SDF can be detected and the SDF with 38% concentration was the most recommended. Puwanawiraj et al., have declared that the SDF with 38% concentration was more effective in caries arresting compared to the solution with 12% concentration.[27] Accordingly, the study population of the current study was treated with 38% SDF. The use of SDF solution with potassium iodide (KI) was also mentioned in the literature. However, the single application of SDF was reported to be more successful compared to the SDF+ KI application in preventing secondary caries development.[28] In the study population of the current retrospective study, the cases were not chosen to be treated with the KI-added solution, considering the suppressing effect of KI on the antimicrobial activity of the SDF solution.[28]

Previously, the researchers assessed the clinical survival and success of SDF-treated primary teeth versus topical fluoride application.[29] The previous studies also compared the clinical success rate of the SMART and hall technique.[30] In the literature, it can be concluded that SDF-only applications play a great part in MIT approaches. Despite the similar success of SDF-only application with topical fluoride systems, these approaches are not affordable in performing the restoration of the tooth and giving the teeth the function of mastication.[31, 32] Accordingly choosing a treatment approach with the feature of rebuilding the lost tooth structure seems like a logical choice.

There are various reports in the literature enlightening the effects of SDF-only applications and the success of SMART technique. However, the effect of carious cavity and tooth location on the success of SMART application was not studied previously. Therefore, it was not possible to compare directly the outcomes of the current study with previous findings. However, a reasonable comparison was performed, and the findings of the current study was discussed with the previous literature especially with the outcomes of SMART applications in the following paragraphs.

Previously, Braga et al.[33] evaluated the effectiveness of SDF in comparison to other non-invasive approaches including cross-tooth brushing and GI fissure sealants in arresting occlusal caries in erupting permanent first molars. The results of this previous study revealed that at 6 months follow-up, applying SDF revealed better caries-arresting activity compared to cross-tooth brushing and GI fissure sealant applications. In another previous study, Dos Santos Jr. et al.[34] assessed the caries-arresting properties of 30% SDF versus GIC application as an intermediate restorative technique. Accordingly, at the evaluations of 12 months, SDF was found to be 1.73

times more effective in caries arresting compared to GIC application.[34] Furthermore, Duangthip et al.[5] have also examined the caries-arresting effects of 3 times SDF application compared to the single application of SDF and fluoride varnish. Eventually, the results of this previous study revealed that SDF was more effective by means of caries arresting, and no significant difference was detected between the results of single and multiple applications of SDF.[5] Although these studies did not recruit SMART technique, still have the importance of providing information regarding the effectiveness of SDF application which is a key factor in the success of SMART treatment and can be mentioned as the supporting literatures of the current study for recruiting SMART technique.

In another previous study, Aly et al.[4] assessed the clinical performance and cost-effectiveness of SMART and ART techniques in primary molars. 59 primary molars were treated and evaluated in the group of SMART while 60 teeth were included in the ART group. The clinical assessments were held by recruiting Modified USPHS criteria. Accordingly, at the end of the 12-month follow-up period, mean survival time for SMART and ART techniques were 11.8 and 11.6 months, respectively and no statistical relation was detected. 72.9% of the teeth revealed Alpha scores while 10.2% of the samples showed Bravo scores at 6 months' assessments of marginal adaptation. These scores were changed to 67.8% (alpha) and 13.6% (bravo) for 12-month assessments. The scores were assessed as 83.1% alpha at the assessments of 6 months and 81.4% at the assessments of 12 months for retention and secondary caries. These results are in line with the outcomes of the current study wherein the successful cases (alpha and bravo scores) for marginal adaptation were 78.8% in the mandible and 38.5% in the maxilla. Furthermore, in the current study, Group-O have a success rate of 88.9 regarding marginal adaptation, similar to this previous observation.

Satyarup et al.[35] assessed the clinical success of SMART compared to ART technique for a period of 9 months. 95 teeth were involved in each group and the results revealed that 58.9% of SMART and 47.8% of ART groups remained intact. Carious teeth with loss of restoration were detected at a rate of 5.6% and 16.7% in the SMART and ART groups, respectively. Parallel with the outcomes of this previous study, in the current study, Group-O cases and the teeth located in the mandible showed similar results lower than 20% of the assessed cases, regarding caries development and loss of restoration. In another similar study, Ahmad et al.[36] assessed the radiographic success of SMART and ART techniques. Accordingly, at the end of 3 months of follow-ups, the SMART group revealed more successful results by performing increased radio-opacity in the neighbourhood of the cavity floor and the authors declared SMART to have a superior remineralization effect compared to ART technique which is also a supporting statement for the reason of recruiting SMART technique in the current study.

Previously, Patel et al.[37] assessed the clinical success of the SMART technique in deep carious lesions in primary teeth for 12 months. The clinical success rate of the cases was detected to be 96.17 at the end of the assessment period and the authors announced removal of infected dentin in deep carious lesions is not required for success. SMART was also declared as a potential approach to managing deep dentine caries with no symptoms.[37] These results are also in line with the outcomes of the current study with rates of clinical success for all assessment criteria (90.2) at 6th months interval. However, this ratio of success decreased to 67.4% for marginal adaptation and to 71.7% for retention, marginal discoloration, and secondary caries in the 12th months assessments.

Clemens et al.[38] applied a SDF solution to the 118 active carious lesions and the cases were monitored for 3 months. At the end of the follow-up period, the teeth were analysed for colour differences, lesion changes (active/passive), and absence/presence of pain. 100 teeth were accepted as successful in the first three months of analyses and the remaining cases were healed successfully following the second application of SDF solution. The high success rate in this previous study can be due to the short follow-up period since the overall success rate in the current study is 96.2% in the 3rd months assessments of marginal discoloration with a following decrease in the remaining period (71.7% for marginal discoloration at 12th months).

Limitations

The current study was a retrospective archive study, and the analyses were made on the recorded images. The results might be affected by the image quality and the conditions that are related to photography techniques. Accordingly, the techniques that was utilized to obtain digital imaging was standardized and all the photographs were taken by one single practitioner and same parameters were adjusted. The case number was also limited with the SMART-applied teeth in the period of the Pandemic and different results can be detected if the study was repeated in an extended population. The restorative material choice was the conventional GIC which was affordable in clinical conditions and different outcomes might be detected if the use of high viscosity GIC was possible. These can be listed as the limitations of the current study and planning a similar prospective study taking into consideration the listed factors may affect the clinical success of the treated cases. However, this research still has the strength of being the first clinical study wherein the comparative assessments of SMART technique regarding tooth location and type of carious cavity was performed.

CONCLUSIONS

Within the limitations of this retrospective study, and according to the successful results of mandibular cases (78.8%) and occlusal caries (88.9%) detected in 12th months assessments it can be concluded that the SMART technique can be utilized in the treatment procedure of uncooperative young patients. Considering the fact that this technique is not able to perform a long-time clinical success (n for successful cases was 53 at 3 months, 51 at 6 months, and 46 at 12 months), the treatment technique can be limited in short time applications which is not longer than 12 months. However, SMART can be a considerable approach in young children with the need for advanced treatment due to ECC especially for arresting caries and delaying the treatment need for a time that the child is mature enough to comply with the complicated dental treatments and to avoid the possible sedation and general anaesthesia procedures. The clinicians should more widely take the advantages of the SMART technique especially with young children which will make a possible decrease in the need of general anaesthesia and sedation procedures. Dental hygienists can also take a part in the performing of SMART technique, especially in the first session wherein SDF is applied, and this attempt may also contribute to the extension of preventive dentistry approaches. However, further clinical studies with longer follow-up periods and larger case numbers should also be conducted in the future to enlighten the effect of the type of carious cavity and tooth location on the long-term success of SMART technique in primary dentition.

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CONFLICT OF INTERESTS

Nothing to declare.

REFERENCES

[1] Uribe SE, Innes N, Maldupa I. The global prevalence of early childhood caries: A systematic review with meta-analysis using the WHO diagnostic criteria. Int J Paediatr Dent. 2021; 31:817-830. doi.org/10.1111/ipd.12783.

[2] Early Childhood Caries: IAPD Bangkok Declaration. Int J Paediatr Dent. 2019; 29:384–386. DOI: 10.1111/ipd.12490.

[3] Wolf TG, Campus G. Cost-effectiveness of treatment decisions for early childhood caries in infants and toddlers: A systematic review. Medicina, 2023; 59.10:1865. DOI: 10.3390/medicina59101865.

[4] Aly AAM, Aziz AMA, Elghazawy RK, El Fadl RKA. Survival Analysis and Cost Effectiveness of Silver Modified Atraumatic Restorative Treatment (SMART) and ART Occlusal Restorations in Primary

Molars: a randomized controlled trial. J Dent. 2023; 128:104379. DOI: 10.1016/j.jdent.2022.104379.

[5] Duangthip D, Chen KJ, Gao SS, Lo ECM, Chu CH. Managing early childhood caries with atraumatic restorative treatment and topical silver and fluoride agents. Int J Environ Res. 2017; 14:1204. DOI: 10.3390/ijerph14101204.

[6] Paglia L. COVID-19 and Paediatric Dentistry after the Lockdown. Eur J Paediatr Dent. 2020; 21:89-89. DOI: 10.23804/ejpd.2020.21.02.01.

[7] Ballikaya E, Esenturk G, Unverdi GE, Cehreli Z. Yeni koronavirüs salgını ve diş hekimliği tedavileri üzerine etkileri. HUSBFD. 2020; 7:92-107. DOI: 10.21020/husbfd.715439.

[8] Greenwall-Cohen J, Greenwall L, Barry S. Silver diamine fluoride - an overview of the literature and current clinical techniques. Br Dent J. 2020; 228:831–838. DOI: 10.1038/s41415-020-1641-4.

[9] Rosenblatt A, Stamford TCM, Niederman R. Silver diamine fluoride: a caries “silver-fluoride bullet”. J Dent Res. 2009; 88:116–122. DOI: 10.1177/0022034508329406.

[10] Zhao IS, Gao SS, Hiraishi N, et al. Mechanisms of silver diamine fluoride on arresting caries: a literature review. Int Dent J. 2018; 68:67-76. DOI: 10.1111/idj.12320.

[11] Crystal YO, Kreider B, Raveis VH. Parental expressed concerns about silver diamine fluoride (SDF) treatment. J Clin Pediatr Dent. 2019; 43:155–160. DOI: 10.17796/1053-4625-43.3.2.

[12] Duangthip D, Fung MHT, Wong MCM, Chu CH, Lo ECM. Adverse Effects of Silver Diamine Fluoride Treatment among Preschool Children. J Dent Res. 2018; 97:395–401. DOI: 10.1177/0022034517746678.

[13] Jiang M, Wong MCM, Chu CH, Dai L, Lo ECM. A 24-month randomized controlled trial on the success rates of restoring untreated and SDF-treated dentine caries lesions in primary teeth with the ART approach. J Dent. 2020; 100:103435. doi.org/10.1016/j.jdent.2020.103435.

[14] Oliveira BH, Rajendra A, Veitz-Keenan A, Niederman R. The effect of silver diamine fluoride in preventing caries in the primary dentition: A systematic review and meta-analysis. Caries Res. 2019; 53:24–32. DOI: 10.1159/000488686.

[15] Jodalli PS, Nayak N, Aparna KS, Badekkila AR. Effectiveness of Silver Diamine Fluoride for Early Childhood Caries Among Children Aged 24 to 72 Months: Protocol for a Randomized Controlled Trial. JMIR Research Protocols. 2023;12: e46144. DOI: 10.2196/46144.

[16] Pisarnturakit P, Detsomboonrat P. Comparison of two caries prevention programs among Thai kindergarten: a randomized controlled trial. BMC Oral Health. 2020; 20:119. DOI:10.1186/s12903-020-01107-5.

[17] Orhan AI, Alkan A, Orhan K, Tezel A, Karaoglanoglu S, Oztas D. Dental caries and associated factors among Turkish children and adults: Findings from the 3rd National Oral Health Survey. Community Dentistry and Oral Epidemiology. 2024; 52: 499-508. https://doi.org/10.1111/cdoe.12943

[18] Ferrari LR, Leahy I, Staffa SJ, Berry JG. The Pediatric Specific American Society of Anesthesiologists Physical Status Score: A Multi-center Study. Anesth Analg. 2021; 132:807-817. DOI: 10.1213/ANE.0000000000005025.

[19] Ricketts D, Innes N, Schwendicke F. Selective Removal of Carious Tissue. Monogr Oral Sci. 2018; 27:82-91. DOI:10.1159/000487838.

[20] Natarajan D. Silver Modified Atraumatic Restorative Technique: A Way Towards “SMART” Pediatric Dentistry During the COVID-19 Pandemic. Front Dent. 2022a; 19.DOI: 10.18502/fid.v19i12.9215.

[21] Bayne SC, Schmalz G. Reprinting the classic article on USPHS evaluation methods for measuring the clinical research performance of restorative materials. Clin Oral Invest. 2005; 9:209-214. DOI:10.1007/s00784-005-0017-0.

[22] Ballikaya E, Ünverdi GE, Cehreli ZC. Management of initial carious lesions of hypomineralized molars (MIH) with silver diamine fluoride or silver-modified atraumatic restorative treatment (SMART): 1-year results of a prospective, randomized clinical trial. Clin Oral Invest. 2022; 26:2197–2205. DOI:10.1007/s00784-021-04236-5.

[23] Natarajan D. Silver Modified Atraumatic Restorative Technique: A Way Towards “SMART” Pediatric Dentistry During the COVID-19 Pandemic. Front Dent. 2022b; 19.DOI: 10.18502/fid. v19i12.9215.

[24] Özgür B, Kargın ST, Ölmez MS. Clinical evaluation of giomer- and resin-based fissure sealants on permanent molars affected by molar-incisor hypomineralization: a randomized clinical trial. BMC Oral Health. 2022;22: 275.DOI: 10.1186/s12903-022-02298-9.

[25] Alkhalaf R, Neves A de A, Banerjee A, Hosey MT. Minimally invasive judgement calls: managing compromised first permanent molars in children. Br Dent J. 2020; 229:459–465. DOI: 10.1038/s41415-020-2154-x.

[26] Bansal K, Shamoo A, Mani K, et al. Silver diamine fluoride modified atraumatic restorative treatment compared to conventional restorative technique on carious primary molars–a randomized controlled trial. J Dent. 2023; 104698.DOI: 10.1016/j.jdent.2023.104698.

[27] Puwanawiroj A, Trairatvorakul C, Dasanayake AP, Auychai P. Microtensile bond strength between glass ionomer cement and silver diamine fluoride-treated carious primary dentin. Pediatr Dent. 2018; 40:291-295.

[28] Zhao IS, Mei ML, Burrow MF, Lo ECM, Chu CH. Effect of silver diamine fluoride and potassium iodide treatment on secondary caries prevention and tooth discolouration in cervical glass ionomer cement restoration. Int J Mol Sci. 2017; 18:340. DOI: 10.3390/ijms18020340.

[29] BaniHani A, Santamaría RM, Hu S, Maden M, Albadri S. Minimal intervention dentistry for managing carious lesions into dentine in primary teeth: an umbrella review. Eur Arch Paediatr Dent. 2022; 23: 667-693.DOI:10.1007/s40368-021-00675-6.

[30] Thakur NS, Tyagi P, Tiwari S, Mali S, Chhattani B, Bhargava S. Comparative Evaluation of Microleakage in Hall's with SDF, Hall's, and Conventional Technique Using Different Luting Cements. Int J Clin Pediatr Dent. 2023; 16: 16.DOI: 10.5005/jp-journals-10005-2510.

[31] Jiang M, Mei ML, Wong MCM, Chu CH, Lo ECM. Effect of silver diamine fluoride solution application on the bond strength of dentine to adhesives and to glass ionomer cements: a systematic review. BMC Oral Health. 2020;20: 1-10.DOI: 10.1186/s12903-020-1030-z.

[32] Khor MMY, Rosa V, Sim CJ, Hong CHL, Hu S. SMART: Silver diamine fluoride reduces microtensile bond strength of glass ionomer cement to sound and artificial caries-affected dentin. Dent Mater J. 2022;41: 698-704.DOI: 10.4012/dmj.2021-319.

[33] Braga MM, Mendes FM, De Benedetto MS, Imparato JCP. Effect of silver diammine fluoride on incipient caries lesions in erupting permanent first molars: a pilot study. ASDC J Dent Child. 2009; 76:28-33.

[34] Dos Santos VE, De Vasconcelos FMN, Ribeiro AG, Rosenblatt A. Paradigm shift in the effective treatment of caries in schoolchildren at risk. Int Dent J. 2012; 62:47–51. DOI:10.1111/j.1875-595X.2011.00088. x.

[35] Satyarup D, Mohanty S, Nagarajappa R, Mahapatra I, Dalai RP. Comparison of the effectiveness of 38% silver diamine fluoride and atraumatic restorative treatment for treating dental caries in a school setting: A randomized clinical trial. Dent Med Probl. 2022; 59:217–223. DOI: 10.17219/dmp/143547.

[36] Ahmad M, Khattab N, Amer M. Radiographic assessment of silver modified atraumatic restorative technique in comparison to atraumatic restorative technique. Egypt Dent J. 2022; 68:1183–1190.DOI: 10.21608/EDJ.2022.111939.1918.

[37] Patel M, Makwani D, Bhatt R, Raj V, Patel C, Patel F. Evaluation of silver-modified atraumatic restorative technique versus conventional pulp therapy in asymptomatic deep carious lesion of primary molars - A comparative prospective clinical study. J Indian Soc Pedod Prev Dent. 2022; 40:383–390. DOI: 10.4103/jisppd.jisppd_360_22.

[38] Clemens J, Gold J, Chaffin J. Effect and acceptance of silver diamine fluoride treatment on dental caries in primary teeth. J Public Health Dent. 2018; 78:63–68. DOI: 10.1111/jphd.12241.