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Evaluation of the effect of resin infiltration (Icon) and sodium fluoride varnish on white spot lesions in Erbil City, Kurdistan Region, Iraq

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ABSTRACT

Background: White spot lesions (WSLs) are subsurface enamel demineralizations that appear as white opacities, often posing an aesthetic concern. This study aims to clinically evaluate the effectiveness of resin infiltration compared to fluoride varnish in arresting WSLs, which helps inhibit caries progression and treats them without the need for drilling.

Methods: The study included patients aged 8-18 years presenting with at least one WSL with an International Caries Detection and Assessment System (ICDAS) score of 1-2 during active management of multiple bilateral lesions (MBAs). Participants were randomly assigned to receive either resin infiltration (Icon) or fluoride application. Follow-up assessments were conducted after six months, with clinical examinations performed using the ICDAS II system for caries evaluation. The SPSS Statistics software version 28 was used for data analysis.

Results: A total of sixty-two patients with an initial diagnosis of white spot lesions participated in the study. No significant differences were observed between groups based on lesion grade, sex, or age. Immediately following treatment, resin infiltration with Icon showed a statistically significant greater improvement in reducing lesion severity compared to sodium fluoride varnish ($p < 0.0001$).

Conclusions: Both resin infiltration and fluoride varnish are practical and effective methods for treating WSLs. The ability of resin infiltration to inhibit caries progression should be considered a viable alternative to fluoride treatments, offering both aesthetic restoration and pore occlusion.

Keywords: *Demineralization, resin infiltration technique, fluoride varnish, white spot lesions*

1. INTRODUCTION

White spot lesions (WSLs), also referred to as early caries lesions (ECLs), represent the initial stage of enamel demineralization, and remineralization therapy is increasingly being adopted as a treatment approach (1, 2). WSLs generally correspond to ICDAS II scores 1–2 (2, 3). Under normal physiological conditions, a balance exists between demineralization and remineralization at the enamel surface due to fluctuations in pH levels. When this balance is disrupted, early caries lesions become evident. Orthodontic treatment with fixed multibracket appliances makes oral hygiene maintenance more challenging, increasing plaque accumulation and caries risk (4, 5).

White spot lesions (WSLs) exhibit a reduction in mineral density and compromised mechanical properties of the affected enamel, along with alterations in molecular composition and surface microstructure (6). The whiter appearance compared to healthy enamel results from increased light scattering within the lesion. This phenomenon primarily occurs because mineral particles in the lesion are surrounded by water instead of mineral-rich enamel. The higher water content causes significant differences in optical properties, leading to shorter photon paths, decreased absorption, and lower transparency. The increased light absorption is mainly due to the greater variation in refractive index between the lesion material and its surroundings (7).

Fluoride-containing products, in various forms of application, are widely employed to prevent and treat WSLs, though with varying degrees of success (8, 9; 10). In addition to fluoride treatments, resin infiltration has emerged as an effective and validated method for managing WSLs. This technique not only improves aesthetics but also helps arrest the early stages of tooth decay (10, 11). One key advantage of resin infiltration is that, owing to the similar refractive index of the infiltrant and the surrounding healthy enamel, the resin appears as a natural part of the tooth structure, blending seamlessly and giving a uniform appearance (12). The resin infiltration technique involves the infiltration of light-curing resins into microscopic holes found within the body of carious lesions, which serve as diffusion channels for acids. By using this method, following polymerization, resins with a high penetration power enter the pores through capillary action and obstruct the passage of acids and fermentable carbohydrates (13, 14).

Icon resin infiltration has been recently introduced as a technique utilizing a highly flowable resinous material that has been shown to provide immediate aesthetic masking of mild white spot lesions (WSLs), helping them blend seamlessly with the surrounding sound enamel (15). Studies have reported that the color of Icon resin infiltration remains stable without significant change for up to six months (16). This minimally invasive method offers an intermediate treatment option between purely preventive approaches and more invasive restorative procedures. The mechanism of action of Icon resin infiltration involves capillary action, allowing the resin to penetrate the porous enamel surface and occlude the micro-porosities within the lesion. This process helps to arrest lesion progression and blocks the pathway for further acid diffusion, thereby halting the development of the lesion (17, 18).

2. PATIENTS AND METHODS

2.1 Study design and participants:

The current study, designed as a clinical trial study, estimated a sample size of 60 patients, aged 6-18 years, presented with WSL. No participants were lost to follow-up. The study was conducted from November 2023 to June 2024 at Khanzad Specialized Dental Center in Erbil City, Kurdistan Region, Iraq, to evaluate the effects of resin infiltration (ICON) and sodium fluoride on white spot lesions within the sample population. The participants were divided into three groups: the first group consisted of patients treated with resin infiltration (ICON, DMG, Germany) following the manufacturer's instructions. After isolating the tooth with a cotton roll, the selected surfaces were cleaned, and the lesions were clinically scored using the ICDAS II (International Caries Detection and Assessment System) visual scoring system. Lesions were examined by gently running a probe over the surface to assess their characteristics. If the lesion felt rough, it was classified as active caries, while smooth surfaces were categorized as non-active lesions. After treatment if the lesion regressed to score 1 and 2 or remain the same score 2 the treatment consider successful but if the lesion progressed to score <3 the treatment consider unsuccessful. Restoration and caries status for each surface were assessed individually (19, 20). Furthermore, Sodium Fluoride is the second patient group that received 5% sodium fluoride varnish applied to the affected tooth after isolating it with a cotton roll. Finally, the control group is only instructed to brush with fluoride toothpaste twice daily. Fluoride interacts with saliva at both the surface and subsurface levels of the enamel. Subsequently, it can combine with phosphate and calcium ions to form larger new crystals that contain higher concentrations of fluoride (fluor-hydroxyapatite), thereby enhancing the remineralization process (Zunxuan et al., 2023)

2.2 Follow-Up and Assessment:

All patients were followed up after six months, and clinical examinations were performed using the ICDAS II system for dental caries assessment. The lesions were examined with a probe to assess their activity, and white spot lesions (WSLs) were classified as successful if they regressed (Scores 0 and 1) or remained unchanged (Score 2). Conversely, the treatment was considered unsuccessful if the lesions progressed (Scores greater than 3) or required restoration during the study period.

2.3 Data management and statistical analysis:

The data recorded on a specially designed questionnaire, collected and entered in the computer via Microsoft Excel worksheet (Excel 2016) and then analyzed using Statistical Package for Social Sciences (SPSS) version 28 and the results were compared between patients with different variables, with a statistical significance level of ≤ 0.05.

Exclusion criteria: It included normal cases with enamel carious cavities in addition to enamel hypoplasia and tetracycline staining were excluded from the study.

Inclusion criteria: All cases aged between 6-18 years of both genders and systemically healthy patients with ICDAS II WSLs on their permanent teeth were included in the data analysis process.

Ethical considerations:

This study was submitted for scientific and ethical approval to the Ethics and Scientific Committees of the Medical Research Ethics Committee at the Kurdistan Higher Council of Medical Specialties (approval number: 1569) on 21/9/2023. The study procedures were explained to the parents of the participants, who provided verbal consent. Participants aged 18 years provided their own written consent

3. RESULTS

No participants were lost to follow-up exclusion. Patients reported no concerns or adverse side effects. Clinically, no adverse effects such as loss of vitality, staining, or gingival alterations were observed in either of the two groups. A total of sixty-two patients with an initial clinical diagnosis were included in this study. Among them, 25 patients (40.32%) were males and 37 patients (59.68%) were females. with a ratio of 1:1.48. The highest rate among males was observed in ICDAS I 9 (14.52%), whereas among females, it was in ICDAS II 14 (22.58%). The lowest rate was found in ICDAS 0 which was 4 (6.45%) in male and in female which was seen in ICDAS III and which was 5 (8.06%).

Table 1: Frequency of ICDAS Grades with the gender

Gender	ICDAS 0	(%)	ICDAS I	(%)	ICDAS II	(%)	ICDAS III	(%)	P value
Male	4	6.45	9	14.52	7	11.29	5	8.06	0.785
Female	7	11.29	11	17.74	14	22.58	5	8.06	
Total	11	17.74	20	32.26	21	33.87	10	16.13	

The mean age and ±SD of the participants was 10.44 ± 2.23 years, ranging from 6 to 18 years, and the median age was 10 years. Table 2 show that the highest proportions was found in ICDAS II 13(20.97%) in the age range of 8-10 years, followed by 11-14 years which was 10 (16.13%) in ICDAS I and the lowest rate was found in ICDAS 0 which is zero in age group 15-18 year. Statistically, there was no significant difference were between grades and age groups (P= 0.3202).

Table 2: Frequency of ICDAS Grades with the ages

Age group	ICDAS 0	(%)	ICDAS I	(%)	ICDAS II	(%)	ICDAS III	(%)	Total	P value
8--10	8	12.90	8	12.90	13	20.97	7	11.29	36	0.3202
11--14	3	4.84	10	16.13	8	12.90	2	3.23	23	
15-18	0	0.00	2	3.23	0	0.00	1	1.61	3	
Total	11	17.74	20	32.26	21	33.87	10	16.13	62	

Table 3 shows the evaluation of the Icon, Sodium fluoride and control groups. There were a significant difference between the groups (P<0.0001). The Icon group demonstrated the most favorable outcomes (Figure 1), with the highest frequency in ICDAS 0 11(17.7%) and ICDAS I 10 (16.1%), reflecting its superior efficacy in reducing lesion severity. Conversely, the control group showed higher frequencies in ICDAS II and III, indicating limited improvement. The Sodium Fluoride group exhibited intermediate outcomes, with participants distributed across ICDAS I and ICDAS II 10 (16.3%), respectively.

Table 3: Frequency of ICDAS Grades with the ICON, Sodium fluoride and control groups

Group	ICDAS 0	(%)	ICDAS I	(%)	ICDAS II	(%)	ICDAS III	(%)	Total	(%)	P value
Icon group	11	17.74	10	16.13	1	1.61	0	0.00	22	35.48	<0.0001
Sodium fluoride group	0	0	10	16.13	10	16.13	1	1.612	21	33.87	
Control group	0	0	0	0	10	16.13	9	14.52	19	30.65	
Total	11	17.75	20	32.26	21	33.87	10	16.13	62	100	

4. DISCUSSION

Enamel demineralization and white spot lesions are among the most common challenges faced by clinicians, not only due to the aesthetic concerns reported by patients but also because they represent the initial stage in the development of carious lesions (21). Among the 62 participants, 25 (40.32%) were male, and 37 (59.68%) were female, resulting in a male-to-female ratio of 1:1.48. Gender differences in outcomes were minimal and statistically insignificant, reinforcing that treatment efficacy is not influenced by gender but rather by the intervention used. The findings are consistent with Zaazou et al. (18) , who studied 49 participants. Female participants presented (30) 61.22%, while male participants presented (19) 38.77%. Furthermore, the age-related trends observed in the study suggest that younger participants (8-10 years) benefited from this treatment, particularly in the Icon group, with higher ICDAS 0 and I scores. This could be due to the higher metabolic activity in younger enamel, which may enhance the treatment response. However, no statistically significant association between age and ICDAS grades was found, indicating that both treatments are broadly applicable across age groups. Additionally, the lower effectiveness in older participants may reflect the challenge of treating more established lesions that have progressed further. The result aligns with Austin et al. (22), Who studied children aged 7–12 years to evaluate caries on the permanent first incisors and molars. Additionally, the age of 12 years is considered the global indicator age by WHO for international comparisons and disease surveillance (23).

The etiopathogenesis of white spots is primarily due to pathogenic bacteria infiltrating the enamel surface, producing acids that dissolve calcium and phosphate ions from the dental structure, leading to these lesions. Primary enamel lesions initially exhibit an apparently intact surface layer, followed by an underlying porous area known as the "body of the lesion" (24, 25). During demineralization, the pore volume of white spot lesions increases, which can alter the refractive index of light due to scattering—this change occurs because of the presence of air or water within the pores. The altered refractive index causes ambient light shining on the teeth to be deflected and scattered, making the lesions visibly opaque clinically (26). It is important to distinguish white spots from fluorosis lesions, developmental enamel hypomineralization, traumatic hypomineralization, and enamel hypoplasia, which may have genetic or environmental origins. These lesions are typically limited to a few teeth, most commonly affecting anterior or front teeth in a localized or generalized manner (27–29). Among the commercially available materials, this study selected ICON, a methacrylate resin with infiltration capability. The primary objective was to evaluate whether resin infiltration effectively halts the progression of early carious lesions by occluding the pore channels. The infiltrant, characterized by its very low viscosity, penetrates the lesion by capillary action, filling the pores. Once filled, the white spots appear similar to the surrounding enamel due to the negligible difference in refractive indices between enamel and the infiltrate. Literature has demonstrated that the use of infiltrating resin is effective in preventing and treating incipient interproximal lesions, particularly in young patients with initial, non-cavitated carious lesions. Resin infiltration has been shown to halt lesion development with satisfactory results (29).

Sodium fluoride is widely favored by patients, particularly at a young age, due to its ease of application and acceptable taste (30). It also serves as a vehicle for delivering bioactive calcium and phosphate ions, which enhance subsurface remineralization (31). Treatment of white spot lesions (WSLs) with resin infiltration (ICON) and sodium fluoride resulted in a reduction of lesion depth, with a statistically significant difference observed between the two treatment groups. A significant difference in treatment efficacy was observed among the groups, with ICON demonstrating superior outcomes, with the highest proportion of participants achieving ICDAS 0 and I score post-treatment. In contrast, the sodium fluoride varnish group showed moderate effectiveness, with participants primarily scoring ICDAS I and II. The control group exhibited limited improvement, with a greater representation in ICDAS II and III scores.

Post-treatment analysis revealed that participants treated with resin infiltration (ICON) achieved an ICDAS 0 score in 17.7% of cases, indicating complete lesion resolution, while those in the sodium fluoride varnish and control group achieved no ICDAS 0 outcomes. This disparity highlights the superior efficacy of resin infiltration in achieving both esthetic and therapeutic goals in white spot lesion management (30, 32). Additionally, sodium fluoride varnish demonstrated a clear advantage over the control group, with significant improvement in lesion status, although less pronounced than the Icon group (33).

5. CONCLUSION

Resin infiltration may be regarded as a promising approach not only for restoring the aesthetics of white spot lesions (WSLs) but also for halting the progression of dental caries by occluding the pores. Moreover, the low-viscosity ICON resin has the ability to rapidly diffuse into the WSLs, providing an immediate improvement in their aesthetic appearance. However, the long-term stability of color improvements in WSLs remains uncertain, warranting further investigation.

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