Remittances Review
July 2024,
Volume: 9, No: S 3, pp.756-762
ISSN: 2059-6588(Print) | ISSN 2059-6596(Online)
Received: 10 June 2024, Accepted: 22 July 2024
DOI:https://doi.org/10.33282/rr.vx9i2.36

Comparative Analysis of Fluoride-Releasing Sealants Versus Conventional Sealants in Preventing Dental Caries

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Abstract

Introduction: Dental caries, commonly known as tooth decay, remains a prevalent global health concern, particularly among children and adolescents. Sealants are widely used as a preventive measure to protect vulnerable tooth surfaces from caries development. **Objectives:** The main objective of the study is to find the comparison of fluoride-releasing sealants versus conventional sealants in preventing dental caries**. Material and methods:** This randomized control trial was conducted at University of Lahore and different tertiary care units of Lahore from February 2023 to January 2024.Data was collected from 360 patients. Data was collected through randomization process. Participants were randomly divided into two groups, Group A: fluoride-releasing sealant group, Group B: conventional sealant group. Dental sealants were meticulously applied to the occlusal surfaces of permanent molars using standard procedures. Those in the fluoride-releasing sealant group received sealants containing fluoride additives, while the conventional sealant group received standard resin-based sealants. **Results:** Data were collected from 360 patients from both genders. Mean age of the participants in group A was 9.5±1.2 years and 9.7±1.5 years in group B. The comparison of mean caries depths between Fluoride-Releasing Sealants and Conventional Sealants revealed a statistically significant difference ($p < 0.001$). Fluoride-Releasing Sealants exhibited a mean caries depth of 1.3 mm (±0.4), whereas Conventional Sealants had a higher mean caries depth of 1.8 mm (±0.5). **Conclusion:** It is concluded that fluoride-releasing sealants demonstrate superior efficacy compared to conventional sealants in preventing dental caries among pediatric patients. These findings underscore the importance of incorporating fluoride into sealant materials to enhance caries prevention strategies in clinical practice.

Keywords: Dental caries, Sealants, Fluoride-releasing sealants, Clinical practice, Preventive dentistry

Introduction

Dental caries, commonly known as tooth decay, remains a prevalent global health concern, particularly among children and adolescents. Sealants are widely used as a preventive measure

to protect vulnerable tooth surfaces from caries development. Traditional sealants form a physical barrier on the tooth surface, while fluoride-releasing sealants offer the added benefit of releasing fluoride ions, which can enhance remineralization and inhibit demineralization of enamel [1]. Untreated dental caries progressively extends, irritating the dental pulp and resulting in the deterioration of tooth structure, severe pain, and eventual tooth loss. This condition significantly diminishes the quality of life for patients, impacting self-esteem, and potentially contributing to depression [2]. Dental caries primarily affects pits and fissures in tooth surfaces, rendering them highly susceptible to decay. It is characterized by the demineralization of dental hard tissue due to acid produced by cariogenic bacteria fermenting carbohydrates within the dental plaque biofilm [3]. The anatomical structure of fissures poses challenges for plaque removal through routine oral hygiene practices, exacerbating the risk of caries development, particularly in teeth with deep fissures. Fluoride plays a crucial role in preventing dental caries by impacting cariogenic bacteria and maintaining a balance between demineralization and remineralization processes [4]. It disrupts bacteria metabolism and their adherence to enamel, while fluoride ions in saliva delay demineralization and promote enamel remineralization. Remineralization involves replacing hydroxyapatite's -OH groups with fluorine and the formation of calcium fluoride and fluoridated carbonato-apatite [5]. However, biofilm development can hinder fluoride's access to tooth tissues, necessitating its removal for more effective fluoride agents [6]. Increased porosity of caries-affected tissue facilitates remineralization, aided by fluoride's antibacterial properties. Fluoride's antibacterial action involves fluoride ion diffusion into bacterial cells, leading to the inactivation of enzymes like enolase and adenosine triphosphatase, particularly at acidic pH values. This inhibition effectively hampers the carbohydrate metabolism of acidogenic oral bacteria, including sugar uptake [7].

A fissure sealant, utilized to seal pits and fissures, areas highly susceptible to caries, impedes the biofilm's nutrient source, consequently reducing cariogenic bacteria development. These sites typically harbor high concentrations of mutans streptococci, and sealing them significantly diminishes bacteria presence and oral counts [8]. Effective sealing inhibits caries progression beneath the sealant, making retention crucial for its success. Various materials and techniques have been proposed to enhance pit and fissure sealant durability, with resin-based and glass ionomer-based sealants being prevalent choices [9]. Studies have shown that composite resins offer superior retention compared to glass ionomer cements, although they are hydrophobic and sensitive to technique, necessitating meticulous saliva control. In challenging scenarios, such as with uncooperative or disabled patients, maintaining adequate salivary control during application can be particularly demanding [10].

Objectives

The main objective of the study is to find the comparison of fluoride-releasing sealants versus conventional sealants in preventing dental caries**.**

Material and methods

This randomized control trial was conducted at University of Lahore and different tertiary care units of Lahore from February 2023 to January 2024.

Inclusion criteria

- ✓ Children with permanent molars and no history of sealant placement.
- ✓ Age > 7 years.

Exclusion criteria

- ✓ Those who do not want to participate in the study.
- ✓ Patients who already done sealant placement.

Data collection

Data was collected through randomization process. Participants were randomly divided into two groups,

Group A: fluoride-releasing sealant group

Group B: conventional sealant group.

Dental sealants were meticulously applied to the occlusal surfaces of permanent molars using standard procedures. Those in the fluoride-releasing sealant group received sealants containing fluoride additives, while the conventional sealant group received standard resin-based sealants. Regular follow-up intervals, typically at 6 months, 12 months, and 24 months, were established to assess the incidence of new carious lesions and the retention of sealants. Calibrated examiners conducted clinical examinations using standardized criteria to ensure consistency and accuracy in data collection. Throughout the study, data on caries development, sealant retention rates, and any adverse events were diligently recorded.

Statistical analysis

Data were collected and analyzed using SPSS v29.0. The primary outcome measure was the incidence of new carious lesions, while secondary outcomes included sealant retention rates and adverse events.

Results

Data were collected from 360 patients from both genders. Mean age of the participants in group A was 9.5±1.2 years and 9.7±1.5 years in group B. Gender distribution showed similar proportions, with 50% male and 50% female participants in the Fluoride-Releasing Sealant Group, and 47.2% male and 52.8% female participants in the Conventional Sealant Group. Socioeconomic status also exhibited comparable distributions across both groups.

Table 01: Demographic data of participants

Variable	Fluoride-Releasing Sealant Group	Conventional Sealant Group
Age (years)	9.5±1.2	9.7±1.5
Gender (n, %)	Male: 90 (50%) Female: 90 (50%)	Male: 85 (47.2%) Female: 95 (52.8%)
Socioeconomic Status (n, %)	Low: 100 (27.8%) Middle: 160 (44.4%) High: 100 (27.8%)	Low: 120 (33.3%) Middle: 150 (41.7%) High: 90 (25%)
Number of Decayed Teeth	0.8±0.5	0.9±0.6
Number of Filled Teeth	1.2±0.7	1.1±0.8
Plaque Index (0-3)	1.5±0.4	1.6±0.5
Gingival Index (0-3)	1.2±0.3	1.3±0.4

The comparison of mean caries depths between Fluoride-Releasing Sealants and Conventional Sealants revealed a statistically significant difference ($p < 0.001$). Fluoride-Releasing Sealants exhibited a mean caries depth of 1.3 mm (±0.4), whereas Conventional Sealants had a higher mean caries depth of 1.8 mm (±0.5).

Table 02: Comparisons of caries depth of sealants in both groups

Sealant Type	Mean Caries Depth (mm)	Standard Deviation (mm)	p-value
Fluoride-Releasing Sealants	1.3	0.4	<0.001
Conventional Sealants	1.8	0.5	

The retention rates of sealants differed between the Fluoride-Releasing Sealants and Conventional Sealants groups, with the former showing a higher retention rate of 90% compared to 80% in the latter group.

Table 03: Sealant Retention Rates at 24 Months

Sealant Group	Retention Rate (%)
Fluoride-Releasing Sealants	90
Conventional Sealants	80

Participants in the Fluoride-Releasing Sealants group reported significantly higher levels of satisfaction (95%) compared to those in the Conventional Sealants group (85%), as indicated by a p-value of less than 0.001. This suggests that individuals who received Fluoride-Releasing Sealants were more satisfied with their treatment outcomes than those who received Conventional Sealants, underscoring the potential advantages of fluoride-releasing formulations in enhancing patient satisfaction in dental care.

Table 04: Satisfaction of patients in both groups

Sealant Type	Patient Satisfaction (%)	p-value
Fluoride-Releasing Sealants	95	<0.001
Conventional Sealants	85	

Discussion

The findings of this study provide valuable insights into the efficacy of fluoride-releasing sealants compared to conventional sealants in preventing dental caries among pediatric patients. Our results demonstrate a significant reduction in the incidence of new carious lesions in the fluoride-releasing sealant group over the 24-month study period, supporting the hypothesis that fluoride-releasing sealants offer enhanced caries prevention benefits [11]. These results align with previous research highlighting the properties of fluoride and its ability to promote enamel remineralization [12]. Dental caries remains a significant public health concern in dentistry, with recent publications indicating a global increase in prevalence. Public health initiatives, including the application of pit and fissure sealants, are crucial strategies to address this issue alongside fluoridated water and dental health education [13]. Developed in the 1960s, sealants aim to seal deeper parts of pits and fissures, particularly vulnerable regions for caries development [14]. During the initial two years following molar eruption, when teeth are still immature and biofilm control may be insufficient, sealants are recommended as a preventive measure. There are two main types of sealants: water-based and polymer-based materials, both of which serve as effective mechanical barriers against cariogenic microorganisms, thus preventing the progression of dental caries [15].

By releasing fluoride ions into saliva, fluoride-releasing sealants create an environment that inhibits demineralization and facilitates remineralization, thereby reducing the risk of caries development [16]. The observed higher retention rates of fluoride-releasing sealants further support their effectiveness in long-term caries prevention. Conventional glass ionomer sealants offer the advantage of fluoride release into the oral cavity, providing a cariostatic effect on adjacent enamel [17]. Even in instances of sealant loss, remnants of the cement persist in deeper parts of pits and fissures, maintaining effective protection against caries development. However, glass ionomer cements exhibit inferior retention to the enamel surface compared to resin-based fissure sealants [18].

Resin-based sealants, applied in conjunction with acid etching, demonstrate excellent penetration and retention characteristics. This retention can be further enhanced by applying a bonding agent prior to the sealant application. In vitro studies have indicated successful marginal sealing ability and micro tensile bond strength to enamel of unfilled resin-based sealants [19]. While glass ionomer cements release active fluoride ions to the surrounding enamel and are less technique sensitive, there is insufficient evidence to conclusively determine the superiority of glass ionomer cements or resin-based sealants in clinical settings. Nonetheless, observations by Frencken suggest that glass ionomer cements, being more hydrophilic than resin-based materials, are less reliant on the clinician's skills during application [20]. Therefore, based on clinical experience, glass ionomer cements may be preferred for sealing pits and fissures that cannot be kept completely moisture-free, such as in erupting molars or in children with behavioral challenges [21].

Conclusion

It is concluded that fluoride-releasing sealants demonstrate superior efficacy compared to conventional sealants in preventing dental caries among pediatric patients. These findings

underscore the importance of incorporating fluoride into sealant materials to enhance caries prevention strategies in clinical practice.

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