



Review article

Retention of pit and fissure sealants versus flowable composites in permanent teeth: A systematic review



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ABSTRACT

Objective: To summarize the available clinical evidence on the relative effectiveness of retention of resin-based pit and fissure sealants (PFS) with that of flowable composites on occlusal surfaces of permanent teeth when evaluated in clinical trials.

Sources: Electronic searches were performed in PubMed and Cochrane Library for the identification of relevant studies, from their inception until February 2020 and an additional search was done with the reference lists of included articles.

Study selection: The review protocol followed the PRISMA guidelines and was registered in PROSPERO (CRD42018112805). The risk of bias of the studies was independently appraised using the revised Cochrane Risk of Bias tool (RoB 2.0).

Data: Ten articles were considered relevant for qualitative synthesis. The data extracted from two of the included articles showed statistically significant difference between the two materials based on their retention potential, of which one article favored superior retention of flowable composites and one article favored higher retention of PFS and the other eight studies showed no significant difference between the two materials.

Conclusion: The current review has shown evidence suggesting the effective retention of resin-based pit-and-fissure sealants and flowable composites when applied to prevent occlusal caries in permanent molars, however, this evidence is of low quality. Carefully designed long-term clinical trials are required to support the results of this review.

Clinical significance: This is an important topic that would be of significant interest in the field of preventive dentistry, where sealants are the primary recommended method to prevent caries. The clinical efficacy of sealants is directly linked to their potential to retain and this systematic review focuses on comparing the relative effectiveness of resin-based pit-and-fissure-sealants with flowable composites in permanent teeth.

1. Introduction

Dental caries is a disease induced by the shift in the balance of activity and composition of the biofilm microflora when exposed to fermentable carbohydrates over a period of time, disturbing the demineralization-remineralization equilibrium [1, 2, 3]. In 2015, the ADA published the Caries Classification System, which defines a non-cavitated lesion as “initial caries lesion development, before cavitation occurs. Non-cavitated lesions are characterized by a change in color, glossiness, or surface structure as a result of demineralization before there is macroscopic breakdown in surface tooth structure” [1, 2]. Eventually, the need for standardization of caries detection and diagnosis in differing environments led to the development of International caries detection

and assessment system (ICDAS). ICDAS has a scoring system that encodes sound tooth surface with no evidence of caries after 5 seconds of air-drying as score 0 [4].

Over the past several decades, the prevalence of caries has diminished in developed countries [5], owing to various means of preventing them either by averting their onset or by implementing interventions, which may halt progression in the early stage of the disease [1, 2, 3]. However, the decline in caries in the occlusal surfaces of permanent teeth has not kept pace with that of those on the smooth surfaces [1, 6].

The occlusal surfaces, especially those on permanent molars, encompass pits, that are small pinpoint depressions located at the junction of developmental grooves and fissures, that are deep clefts between adjoining cusps [7]. The dental plaque, when accumulated in these pits

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and fissures, can mature undisturbed, making their mechanical removal difficult. Hence, a comprehensive approach in preventing caries is by the use of a fully-retained fissure sealant [8], which act locally by forming a physical barrier between the fissure microflora and the oral environment, thus averting the exchange of their metabolic products [1, 9].

A range of studies has been conducted in order to compare and verify the advantages of the different materials used as fissure sealants. Deery et al, confirmed that regarding the material used, there are no significant differences between the use of resin-based and ionomeric-based sealants [10]. The clinical efficacy of sealants is directly linked to their potential to be retained in the occlusal pits and fissures [11] and it has been reported that the major disadvantage of sealants, irrespective of the material used, was their capacity to retain [12]. Any dental material, when exposed to the oral environment, is subjected to varying factors, like the salivary composition, pH, and flow. The salivary pH ranges from neutral to acidic, and alterations in the mechanical properties of restorative materials can occur at lower pH levels. Various other factors also impede sealant retention including polymerization stress, thermocycling, water sorption, and deflection by occlusal forces, and the literature indicates that about 5–10% of sealant volume is lost per year [13].

By adding inorganic filler particles to sealant formulations, manufacturers attempted to increase their wear resistance. Amongst the various materials being used as PFS, flowable composites are gaining popularity, owing to their favorable properties such as easy handling, low elastic modulus and low viscosity [13, 14, 15, 16, 17]. Flowable composites have lower filler volume (37–53%) than conventional composites, that aids in modifying the viscosity of these materials [14], thereby enabling them to be packed into small preparations that would be difficult to fill otherwise [15]. Studies have reported comparable retention rates, greater wear resistance, and lower porosity for flowable composites compared to conventional unfilled pit and fissure sealants [16–19].

There have been systematic reviews in the past that have evaluated the clinical effectiveness and safety of pit and fissure sealants, either alone or in comparison with another type of sealant material and fluoride varnishes [20, 21]. However, the aim of the current systematic review was to evaluate the relative effectiveness of retention of resin-based pit and fissure sealants with flowable composites on occlusal surfaces of permanent teeth when evaluated in clinical trials.

2. Materials and methodology

2.1. Protocol and registration

This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement for reporting systematic reviews. The protocol of the review study design was registered at the Prospective register of systematic reviews (PROSPERO) under the registration number CRD42018112805.

2.2. Literature search strategy

For identification of studies for this review, a detailed search was performed in the following databases: PubMed and Cochrane Central Register of Controlled Trials, from their inception till January 2020. The search terms followed the syntax rules adapted for each database based on the PICOS question. Additional keywords related to the theme of this review were used through the Boolean operators (OR, AND) to combine search words (Table 1). A complementary search was also conducted by screening the references of the selected articles, previously published reviews in the topic, and textbooks to find any that did not appear in the database search and also in the clinical trial registry (clinicaltrials.gov.in).

Table 1. Search strategies and electronic databases searched.

Search strategies and electronic databases searched:
Pubmed: 63
(((((pit and fissure sealants)) OR fissure sealants) OR dental sealants) OR (pit and fissure sealants[MeSH Terms])) AND (((flowable composite) OR composite resin[MeSH Terms]) OR dental flowable resin composite) AND ((retention) OR retention time) AND (((permanent teeth) OR adult) OR secondary teeth)
Cochrane: 17
#1 fissure
#2 MeSH descriptor: [Pit and Fissure Sealants] explode all trees
#3 dental
#4 resin
#5 composite
#6 sealant
#7 (#1 or #3 or #4 or #5) and #6
#8 #2 or #7
#9 flowable composite
#10 dental flowable resin composite
#11 #9 or #10
#12 retention
#13 #8 and #11 and #12
Clinical trial registry (clinicaltrials.gov.in): 33
Pit and fissure sealants
Fissure sealants
Dental sealants

2.3. Research question

The research question for this review was formulated in PICOS format (participants, interventions, comparisons, outcomes and study design), based on PRISMA guidelines [22]: ‘Are resin-based pit and fissure sealants (I) relatively effective in retention (O) on caries-free occlusal surfaces of permanent teeth (P) when compared to flowable composites (C) when evaluated in clinical trials (S)?’

2.4. Eligibility criteria

The following eligibility criteria for the terms used in the research were defined to identify clinical trials based on the elements of the PICOS question:

1. Population (P):
 - Studies on permanent teeth with no clinically detectable caries.
 - Studies on which lesions were included in which no demineralized tissue was removed (beyond acid etching for bonding) before the application of the intervention.
 - Studies on which lesions were diagnosed by visual/tactile assessment/radiographs
2. Intervention (I): Pit and fissure sealants
3. Comparison (C): Flowable composites
4. Outcome (O): Retention of sealants (either complete or partial loss of sealant on visual examination during periodic recall) with a follow-up of at least 12 months.
5. Study design (S): Clinical studies (Randomized/controlled/split-mouth clinical trials)

The following exclusion criteria were applied: (1) Studies on primary teeth. (2) Studies with less than 12 months of clinical follow-up. (3) Studies not in the English language. (4) Reviews, case reports and case series, observational and descriptive studies, and laboratory research.

2.5. Inclusion and extraction of data

In the initial screening, two reviewers (H.R and R.A) evaluated independently the titles and abstracts of retrieved publications related to the encompassed research question. The full text screening of the articles was then performed to identify the articles that met the inclusion criteria.

After the definition of the included articles, data extraction was performed. Any disagreements in the inclusion of articles or data extraction were resolved by a third reviewer (A.G). In case of missing or incomplete data, authors were contacted to obtain more details by electronic message.

2.6. Quality assessment

The risk of bias was assessed using 'Cochrane Collaboration's tool for assessing risk of bias'. The following domains were used to determine if each component had a low, moderate or high risk of bias: sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, assessment of outcome data, selective outcome reporting, other sources of bias. Studies with no 'high risk of bias' ratings were considered to have an overall low risk of bias, one 'high risk of bias' rating moderate risk of bias, and more than one 'high risk of bias' rating a high overall risk of bias.

3. Results

3.1. Search results

A flowchart describing the selection process is shown in Figure 1. With the defined criteria, the initial searches retrieved 143 potential articles. Four articles were selected by manually screening the references of previous reviews relevant to the title, making a total of 147 articles. After duplicate removal, 138 articles remained; the title and abstract screening revealed fourteen articles of relevance. After full-text screening, four articles were excluded with reasons [9, 23, 24, 25] (Table S1), and ten articles [16, 17, 18, 19, 26, 27, 28, 29, 30, 31] that fulfilled the eligibility criteria were included in the present qualitative review.

3.2. Study characteristics

The general information of the selected studies is summarized in Table 2. The included ten articles were published between the years 2002–2019. These studies were carried out in Brazil [16], Florida [27], Croatia [18, 28], Egypt [29], Iran [30], Turkey [17, 19, 26] and India [31] and involved 533 patients in the age group of 4–22 years and a total of 1800 permanent molars were sealed according to the intervention and

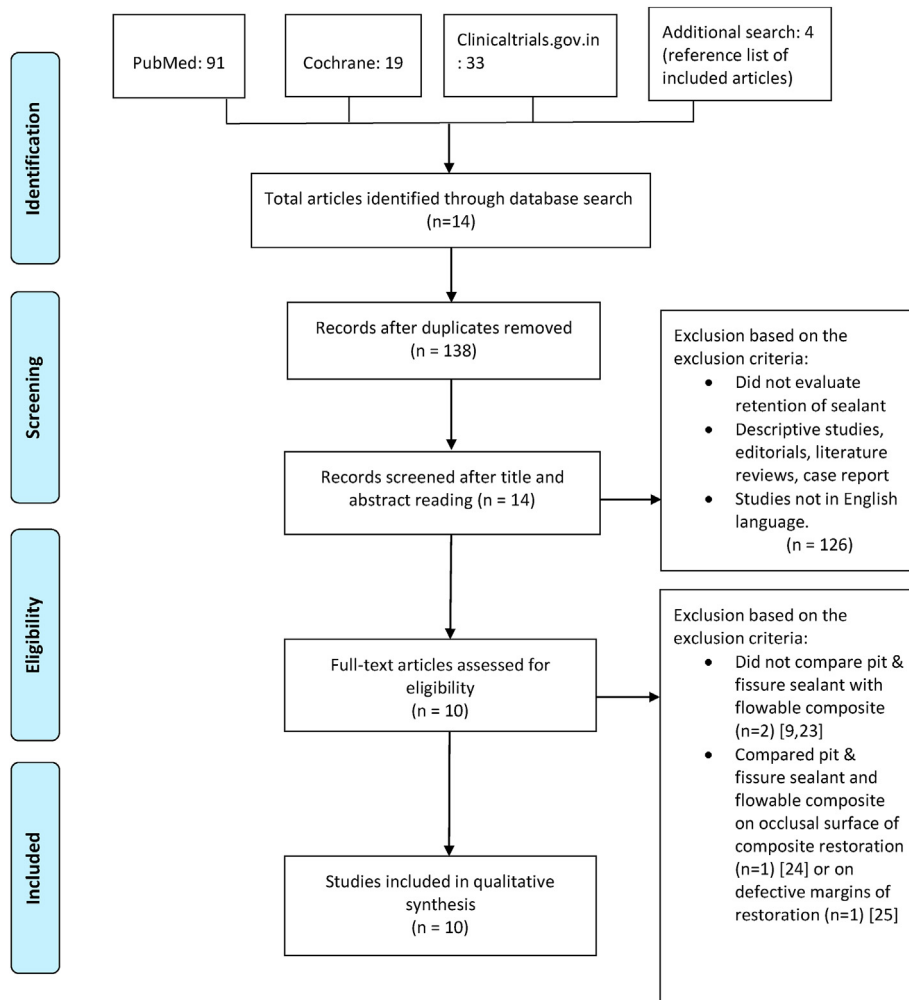


Figure 1. A flow diagram showing the process from identification to inclusion of the studies.

Table 2. General characteristics of the included studies.

Author and Year	Country	Design of Study	Age range of participants	Total number of participants	Intervention & Comparison	Follow-up period	Scoring criteria
Autio Gold JT, 2002	Florida	Split-mouth design	6–11 years	32 children, 118 teeth	Delton, CuRay-Match	1, 6 and 18 months	Autio Gold JT 2002
Corona et al, 2005	Brazil	RCT- half-mouth design	4–7 years	40 children, 80 teeth	Fluoroshield, Flow-It!	6 and 12 months	Tonn & Ryge criteria
Dukic et al., 2007	Croatia	Clinical trial	7–17 years	41 participants, 100 teeth	Helioseal Clean Chroma, Teethmate F1, Tetric N Flow	24 months	Dukic & Glavinia 2006
Dukic. Walter et al, 2007	Croatia	Clinical trial	6–15 years	130 children, 326 teeth	Helioseal Clean Chroma, Teethmate F1, Admira Seal, Fissurit FX, Tetric Flow, Admira Flow	12 months	Pardi et al 2004
Amin et al., 2008	Egypt	Controlled clinical trial	7–10 years	15 participants, 90 teeth	Helioseal F, Tetric Flow	1, 6 months, 1 and 2 years	Boksman & Carson 1998
Jafarzadeh et al., 2009	Iran	RCT - split mouth design	6–9 years	40 participants, 80 teeth	Concise, Filtek Supreme	3, 6, 12 months	Garcia & Godoy 1986
Oba et al., 2012	Turkey	RCT– split mouth design	9–20 years	35 participants, 122 teeth	Fissurit F, Admira Flow, Grandio Flow	12 & 24 months	Garcia & Godoy 1986
Erdemir et al., 2014	Istanbul, Turkey	RCT - split mouth design	16–22 years	34 participants, 220 teeth	Helioseal F, Tetric EvoFlow	6, 12 & 24 months	Erdemir 2014
Kucukyilmaz et al, 2015	Izmir, Turkey	RCT - split mouth design	6–12 years	136 participants, 544 teeth	Fissurit FX, Grandio seal, Tetric EvoFlow, Vertise Flow	3.6,12,18 and 24 months	Kucukyilmaz et al criteria
Singh C et al, 2019	India	RCT	6–9 years	30 participants, 120 teeth	Clinpro™, Filtek™ Z350XT	3.6.9 and 12 months	Modified Simonsen's criteria

comparison group of each included study. The follow-up interval of the studies ranged from 1-24 months, with a period minimum of up to 12 months.

Three studies had isolated the teeth to be sealed with rubber dam [16, 29, 31], whereas the other studies had utilized cotton rolls and saliva ejector as a means of isolation. Etching was done with 37% phosphoric acid at varying time periods for each of the study, and the bonding agents applied were cured for about 10–20 s and the pit and fissure sealants and the flowable composites were cured for about 40 s in all the included studies.

In the study by Amin [29], there was no loss of sealant in 96% of the sealed teeth in all the groups for upto 2 years. The permanent teeth that were sealed with flowable composite remained fully-sealed over a one-year follow-up period in the randomized clinical trial by Corona et al [16], whereas partial loss of sealant was noticed on two teeth in the conventional PFS group. Jafarzadeh et al [30] noted partial loss of flowable composite for four teeth at 12-month follow-up, and for six teeth in the conventional fissure sealant group, however, for both the materials, there was no total loss of sealants over 12-months follow-up. In the study by Dukic et al [28], all materials showed the highest partial loss of about one-third of the sealant after 24-month period. Within the conventional PFS materials, the highest partial loss was established for Teethmate F1 (30.0%), and the lowest for Helioseal Clear Chroma (18.2%). Oba et al [17] noted lower complete loss rates in PFS group compared to flowable composites over 24 month period, and partial loss was noted in 16.2% of the PFS sealed teeth compared to both the flowable composites. Erdemir et al [19] observed total loss of sealants in four subjects treated with flowable composite and only two subjects treated with PFS showed total loss of sealants.

The results of the data extracted from two of the included articles showed a statistically significant difference between the two materials based on their retention potential, of which one article favored superior retention of flowable composites [26] and one article favored higher retention of PFS [17] and the other eight studies [16, 18, 19, 27, 28, 29, 30, 31] showed no significant difference between the two materials.

3.3. Risk of bias assessment

Figure 2 shows the methodological quality of the individual studies evaluated using the Cochrane RoB 2.0 tool. Six studies [16, 17, 19, 27, 30] showed low risk of bias with regard to selection bias. Only three studies [19, 26, 30] had blinded the outcome assessor, amongst which only two [19, 26] had blinded the participant and personnel. There were no concerns regarding attrition and reporting bias. Only Erdemir et al [19] and Kucukyilmaz et al [26], presented with an overall low risk of bias amongst the included studies.

4. Discussion

To improve the quality of this systematic review, we included only clinical trials for the systematic review analysis. Also, only studies involving conventional resin-based pit-and-fissure sealants and flowable composites as the sealant materials by the investigators were included in this systematic review. Two studies [19, 30] were single-blinded randomized clinical trials, where the outcome assessor was blinded to the treatment groups and only the study by Kucukyilmaz et al [26] was double-blinded. In all the included studies, the teeth surfaces were cleaned prior to treatment either by pumice prophylaxis or by scaling. In the study by Corona et al, the dental surfaces were cleaned with pumice in Robinson bristle brushes to remove salivary pellicle and the remaining dental biofilm. Singh C et al [31] had advocated air abrasion as a measure to reach the deep pits and fissures inaccessible with pumice prophylaxis or acid etching and demonstrated that this pseudo-mechanical method showed better retention of both conventional PFS and flowable composites. Isolation with rubber dam was done in three studies to prevent salivary contamination and facilitate operatory procedures. The

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Amin et al., 2008	?	-	-	-	+	+	?
Autio Gold JT 2002	+	-	-	-	+	+	?
Corona et al 2005	+	-	-	-	+	+	?
Dukic et al., 2007	-	-	-	-	+	+	+
Dukic Walter et al, 2007	?	-	-	-	+	+	+
Erdemir et al., 2014	+	+	+	+	+	+	+
Jafarzadeh et al., 2009	+	+	-	+	+	+	?
Kucukyilmaz et al., 2015	+	+	+	+	+	?	+
Oba et al., 2012	+	-	-	-	?	+	+
Singh C et al, 2019	-	-	-	-	+	+	?

Figure 2. Risk of bias summary: review author's judgements about each risk of bias item for each included study.

additional step of etching with 37% phosphoric acid increases the surface energy of the enamel and forms micro-retentive irregularities on the surface of the enamel [26], which increases the overall retention.

Several authors have assessed the retention of sealants after one-year, which might be considered as a short period for evaluation of clinical success. According to Dennison et al, most sealant failures occur at six months following application [32]. Hence the duration of 12 months was considered as a minimum period required to be included in this review. Five studies had a follow-up of up to 24 months [17, 19, 26, 28, 29].

Three studies [18, 19, 28] reported by visual examination, the presence or absence of caries in association with the placement of sealants for varying follow-up periods. In one study [29], the author had reported the occurrence of caries and the salivary antibacterial activity. It was found that, despite the flowable composite performing better in retention rate, the caries occurrence was higher with flowable composite and least with glass-ionomer sealant than resin-based sealant. Similarly, there was a maximum reduction of salivary *Streptococcus mutans* count for glass-ionomer sealants, which may be reasoned out due to the fluoride-releasing property of the ionomeric materials.

In his study, Autio-Gold [27] found that the unfilled sealant showed better results compared to medium-filled composite, which was similar to the results of Oba et al [17]. Jafarzadeh et al [30] found similar results for both materials when used with adhesive systems. The higher filler load of the flowable composite can affect their penetration capacity into the deeper fissures, arguing why the conventional PFS, with their lowest filler volume, performed better [19].

Erdemir et al [19] indicated that the retention rate was lower in conventional PFS, whereas higher caries incidence was demonstrated by flowable composite with no statistically significant difference between the groups. The results of a 24-month evaluation by Kucukyilmaz and Savas indicated that flowable composite used with an adhesive system was superior to conventional resin-based sealants. In addition, a self-adhesive flowable composite without an adhesive system was evaluated in their study, which showed the least retention amongst other groups. However, the findings of Bagherian et al. [33] indicated that an adhesive system under resin-based sealants can increase their retention potential, and this could have affected the results of the study by Kucukyilmaz. Amin, in his study, found that the use of flowable composites as fissure sealant materials yielded slightly better retention than the conventional resin-based fissure sealant, where no adhesive system was used in both the groups. In one of the hallmark study by Corona et al [16], the authors had assessed the retention rate in both primary and permanent teeth and found that there was complete retention of 95% for conventional pit and fissure sealant group and 100% for the flowable composite group over a one-year follow-up period in the evaluated permanent teeth. Dukic et al [28] noted that amongst his experimental groups, there was not a single case of caries incidence in the teeth sealed with the flowable composite, deducing that flowable composite resins when used in combination with dentin bonding agents, showed enhanced strength of the adhesive bonding to enamel in fissures by the formation of resin-tags and thus better retention rates. Additionally, an in-vitro study by Aguilar et al [13] has reported superior performance of flowable composites than conventional PFS with no statistically significant difference concerning their depth of penetration and retention rates.

The high filler volume in flowable composites lowers their polymerization shrinkage, thereby lowering the chance of microleakage, which consequently ameliorates the retention. On average, about 5% volume of the flowable composites undergoes polymerization shrinkage. Kusai Baroudi et al, concluded that the filler-fraction of flowable composites greatly influenced their polymerization shrinkage-strain [15]. Additionally, the resin is elastic with less surface porosity and during mastication, it has durability with contraction and expansion characteristics relative to the enamel. Also, the wear resistance of the flowable composite is improved due to the presence of higher filler content, thereby decreasing the chance of partial or total sealant loss [34]. These factors could contribute to the retention rate of flowable composites.

The results of the included studies presented with large heterogeneity through different statistical analysis and variations in methodology and scoring criteria, making it difficult to compare the results. The risk of bias was high for most included studies [17, 19, 26, 27, 30], and low for one study by Erdemir et al [19] in all the domains. To minimize the risk of bias, it is expected that future research must be conducted with high methodological rigor aimed at better matching of clinical parameters used in the trials such as the type and viscosity of the materials used, the method of application of the material, proper cleaning of pits and fissures, appropriate acid etching of surfaces and maintaining a dry field uncontaminated by saliva until the sealant is placed and cured is mandatory. Variables like operator experience, familiarity and standardized scoring criteria should be encouraged to validate the findings.

5. Conclusion

The current review has shown evidence suggesting the effective retention of resin-based pit-and -fissure sealants and flowable composites when applied to prevent occlusal caries in permanent molars, however,

this evidence is of low quality. With the current evidence of the included studies, it is not possible to reach conclusions about the superiority of retention rate of one material over the other.

To answer the question of the current review, further carefully designed randomized clinical trials comparing the conventional fissure sealants with flowable composites are required. Long-term trials measuring the outcome of dental caries after sealant application in permanent teeth will provide better guidance for clinicians.

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Competing interest statement

The authors declare no conflict of interest.

Additional information

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References

- J.T. Wright, M.P. Tampi, L. Graham, C. Estrich, J.J. Crall, M. Fontana, et al., Sealants for preventing and arresting pit-and-fissure occlusal caries in primary and permanent molars, *J. Am. Dent. Assoc.* 147 (8) (2016 Aug) 631–645, e18.
- D.A. Young, B.B. Nový, G.G. Zeller, R. Hale, T.C. Hart, E.L. Truelove, et al., The American dental association caries classification system for clinical practice, *J. Am. Dent. Assoc.* 146 (2) (2015 Feb) 79–86.
- A.F. Paes Leme, H. Koo, C.M. Bellato, G. Bedi, J.A. Cury, The role of sucrose in cariogenic dental biofilm formation—new insight, *J. Dent. Res.* 85 (10) (2006) 878–887.
- M. Gupta, N. Srivastava, M. Sharma, N. Gugnani, I. Pandit, International caries detection and assessment system (ICDAS): a new concept, *Int. J. Clin. Pediatr. Dent.* 4 (2) (2011 Aug) 93–100.
- M.D. Lagerweij, C. van Loveren, Declining caries trends: are we satisfied? *Curr. Oral Health Rep.* 2 (4) (2015 Dec) 212–217.
- J. Beauchamp, P.W. Caufield, J.J. Crall, K. Donly, R. Feigal, B. Gooch, et al., Evidence-based clinical recommendations for the use of pit-and-fissure sealants, *J. Am. Dent. Assoc.* 139 (3) (2008 Mar) 257–268.
- Stanley J. Nelson, *Wheeler's Dental Anatomy, Physiology, and Occlusion*, tenth ed., 2014.
- L.J. Brown, L.M. Kaste, R.H. Selwitz, L.J. Furman, Dental caries and sealant usage IN U.S. CHILDREN, 1988-1991: selected findings from the third national health and nutrition examination survey, *J. Am. Dent. Assoc.* 127 (3) (1996 Mar) 335–343.
- V. Pardi, A.C. Pereira, G.M.B. Ambrosano, M. de C. Meneghim, Clinical evaluation of three different materials used as pit and fissure sealant: 24-months results, *J. Clin. Pediatr. Dent.* 29 (2) (2005 Jan) 133–138.
- C. Deery, Strong evidence for the effectiveness of resin based sealants: question: what are the effects of different types of fissure sealants in preventing caries in permanent teeth in children and adolescents? *Evid. Base Dent.* 14 (3) (2013 Sep) 69–70.
- N. Fatima, Influence of extended light exposure curing times on the degree of conversion of resin-based pit and fissure sealant materials, *Saudi Dent. J.* 26 (4) (2014 Oct) 151–155.
- R.J. Feigal, Sealants and Preventive restorations: review of effectiveness and clinical changes for improvement, *Pediatr. Dent.* 20 (1998) 2.
- F.C.P. Pires-de-Souza, F. Aguilar, B. Drubi-Filho, L. Casemiro, M.G.C. Watanabe, Retention and penetration of a conventional resin-based sealant and a photochromatic flowable composite resin placed on occlusal pits and fissures, *J. Indian Soc. Pedod. Prev. Dent.* 25 (4) (2007) 169.
- Z. Ergüçü, L.S. Türkün, E. Önem, P. Güneri, Comparative radiopacity of six flowable resin composites, *Operat. Dent.* 35 (4) (2010 Jul) 436–440.
- K. Baroudi, Flowable resin composites: a systematic review and clinical considerations, *J. Clin. Diagn. Res.* (2015) [Internet] [cited 2020 Apr 28]; Available from: http://jcdr.net/article_fulltext.asp?issn=0973-709x&year=2015&volume=9&issue=6&page=ZE18&issn=0973-709x&id=6129.
- S.A.M. Corona, M.C. Borsatto, L. Garcia, R.P. Ramos, R.G. Palma-Dibb, Randomized, controlled trial comparing the retention of a flowable restorative system with a conventional resin sealant: one-year follow up, *Int. J. Paediatr. Dent.* 15 (1) (2005 Jan) 44–50.
- A.A. Oba, I.S. Sönmez, E. Ercan, T. Dülgergil, Comparison of retention rates of fissure sealants using two flowable restorative materials and a conventional resin sealant: two-year follow-up, *Med. Princ. Pract.* 21 (3) (2012) 234–237.
- W. Duki, O. Luli, Clinical comparison of flowable composite to other fissure sealing materials – a 12 Months study, *Coll. Antropol.* 6 (2007).
- U. Erdemir, H.S. Sancakli, B.C. Yaman, S. Ozel, T. Yucel, E. Yildiz, Clinical comparison of a flowable composite and fissure sealant: a 24-month split-mouth, randomized, and controlled study, *J. Dent.* 42 (2) (2014 Feb) 149–157.
- A. Ahovuo-Saloranta, H. Fors, T. Walsh, A. Hiiri, A. Nordblad, M. Mäkelä, et al., Sealants for preventing dental decay in the permanent teeth, in: *The Cochrane Collaboration* (Ed.), *Cochrane Database of Systematic Reviews* [Internet], John Wiley & Sons, Ltd, Chichester, UK, 2013 [cited 2020 Apr 28]. p. CD001830.pub4.
- A. Ahovuo-Saloranta, H. Fors, A. Hiiri, A. Nordblad, M. Mäkelä, Pit and fissure sealants versus fluoride varnishes for preventing dental decay in the permanent teeth of children and adolescents, in: *Cochrane Oral Health Group* (Ed.), *Cochrane Database Syst Rev* [Internet], 2016 Jan 18 [cited 2020 Apr 28].
- D. Moher, A. Liberati, J. Tetzlaff, D.G. Altman, P. Group, Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement, *Int. J. Surg.* 8 (2010) 336–341.
- Vr Reddy, N. Chowdhary, K. Mukunda, N. Kiran, B. Kavyarani, M. Pradeep, Retention of resin-based filled and unfilled pit and fissure sealants: a comparative clinical study, *Contemp. Clin. Dent.* 6 (5) (2015) 18.
- E. Fernández, J. Martín, P. Vildósola, J. Estay, O. de Oliveira Júnior, V. Gordan, et al., Sealing composite with defective margins, good care or over treatment? Results of a 10-year clinical trial, *Operat. Dent.* 40 (2) (2015 Mar) 144–152.
- J. Estay, C. Bersezio, J. Faune, M.P. Correa, P. Angel, J. Martín, E. Fernández, Effects of sealing marginal occlusal defects of composite restorations with a nanofiller-reinforced flowable resin composite: a double-blind, randomised clinical trial with one-year follow-up, *Oral Health Prev. Dent.* 16 (6) (2018) 491–497.
- Kucukyilmaz E, Savas S. Evaluation of different fissure sealant materials and flowable composites used as pitand-fissure sealants: a 24-month clinical trial. 37(5): 6.
- J.T. Autio-Gold, Clinical evaluation of a medium- filled flowable restorative material as a pit and fissure sealant, *Operat. Dent.* 27 (4) (2002 Jul-Aug) 325–329.
- W. Dukic, D. Glavina, Clinical evaluation of three fissure sealants: 24 month follow-up, *Eur. Arch. Paediatr. Dent.* 8 (3) (2007 Sep) 163–166.
- H.E. Amin, Clinical and antibacterial effectiveness of three different sealant materials, *J. Dent. Hyg.* 82 (5) (2008) 10.
- Jafarzadeh M, Malekafzali B, Tadayon N, Fallahi S. Retention of a flowable composite resin in comparison to a conventional resin-based sealant: one-year follow-up. *J. Dent.* 7(1):5.
- C. Singh, K. Kaur, K. Kapoor, Retention of pit and fissure sealant versus flowable composite: an in vivo one-year comparative evaluation, *J. Indian Soc. Pedod. Prev. Dent.* 37 (4) (2019) 372.
- J.B. Dennison, L.H. Straffon, F.G. More, Evaluating tooth eruption on sealant efficacy, *J. Am. Dent. Assoc.* 121 (5) (1990 Nov) 610–614.
- A. Bagherian, A. Sarraf Shirazi, R. Sadeghi, Adhesive systems under fissure sealants: yes or no? *J. Am. Dent. Assoc.* 147 (6) (2016 Jun) 446–456.
- A. Bagherian, A.S. Shiraz, Flowable composite as fissure sealing material? A systematic review and meta-analysis, *Br. Dent. J.* 224 (2) (2018 Jan) 92–97.