REVIEW ARTICLE

Clinical Effectiveness of Air Abrasion When Compared to Conventional Acid-etching Technique in Enhancing the Retention of Pit and Fissure Sealants: A Systematic Review

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Abstract

Purpose: The purpose of our study was to perform a systematic review to assess and compare the effectiveness of the air abrasion technique with that of the conventional acid-etching technique performed before the placement of pit and fissure sealants.

Materials and methods: A search of studies was conducted in May 2021 using PubMed, Cochrane Library, and Google Scholar databases. Clinical trials in the English language between 1997 and 2019 were included. The quality of the studies was analyzed using the Cochrane Collaboration tool.

Results: The search retrieved 276 references, out of which seven studies were included for a qualitative analysis. In these seven studies, the risk of bias across the Cochrane tool's domains varied from low to high. All the included studies considered acid-etching as a comparator to air abrasion technique either used alone or as an adjunct to acid-etching technique.

Conclusion: When coverage of sealants or their retentivity was compared at different time intervals, it was more in the acid-etching group than in the air abrasion group. Similarly, carious lesions were seen more in the air abrasion group than in the acid-etching group. The air abrasion technique followed by acid-etching brought superior retention properties of sealants than the acid-etching technique alone.

Keywords: Air abrasion, Acid-etching, Pit and fissure sealants, Retentivity, Systematic review.

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Introduction

Dental caries is an infectious, multifactorial, and transmissible disease associated with a rise in acid-producing bacteria in the biofilm.[1] Caries incidences among various teeth vary considerably and hugely depend upon the tooth morphology, time of eruption, and positioning of the tooth in the oral cavity.[2] The occlusal pits and fissures of permanent first molars are most commonly affected by caries due to their complex morphology.[3] Furthermore, these teeth, in particular, have a much greater propensity to develop dental caries soon after tooth eruption. The extremely diverse shape of these fissures ranging from broad to narrow funnels, manifold invaginations with inverted Y-shaped divisions, and constricted hourglasses, makes the surface highly prone to caries susceptibility.

Various techniques for preventing pit and fissure caries, like providing mechanic plaque control, application of topical fluorides, antimicrobial varnishes, and sealants, are suggested in most of the studies.[4] Also, more invasive techniques such as mechanical eradication of the fissures,[5] prophylactic odontotomy,[6] and treating the teeth chemically with silver nitrate[7] are also considered for caries-free occlusal surfaces. However, out of all these preventive treatment modalities, sealant application is considered to be a preferred method for the protection of the occlusal surface of teeth from dental caries.[8] This is because, firstly, the placement of pit and fissure sealant is a noninvasive technique, which is relatively easy to perform, and secondly, it largely wards off the initiation of caries and can be used at the community level for caries prevention. Furthermore, the release of fluoride from fluoridated sealants can confer protection to surrounding areas as well.[9] However, it is equally important for the sealant to stay seated over the occlusal surface of the teeth as desired for a long time. The tendency of sealants to retain for a good amount of time effectively renders a caries-free tooth surface. On the other hand, failure in the retentive property of pit and fissure sealant is discerned by an early loss, usually within the 1st year after application, which majorly occurs due to inadequate adhesion or by subsequent failure of the sealant when subjected to wear.[10]

To inculcate a good retention tendency, the most commonly preferred technique is acid-etching, wherein many practitioners carry out the mechanical preparation of pits and fissures before the application of sealant. Also, the literature supports the fact that acid-etching increases the receptivity of the tooth to bond with the sealant. However, it has also been witnessed that debris or pellicles are not adequately isolated from the bottom of the

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fissures and pits using the traditional acid-etching technique. To overcome this, many other techniques were advocated to obtain favorable results. Air abrasion is one such technique that allows total cleaning of the grooves before the sealant is placed. Although the technique was introduced in the field of dentistry in 1945, its popularity increased only recently with the advent of minimally invasive dentistry.[11] The organic plug material is very efficiently removed from the fissures due to the abrasive particles used, thereby resulting in profound penetration of the sealant into the fissures and helping reduce caries.[12] The technique of air abrasion most commonly works by using a jet of aluminum oxide (Al_2O_3) particulates, which is usually produced from compressed air.[13,14] Also, some studies state that, besides roughening the enamel surface mechanically, the air abrasion technique also opens up fissures and removes caries before sealant placement.[4] This technique, therefore, is less technique-sensitive and eliminates various steps that are required in the traditional technique, thereby reducing working time. Although many studies in the past have mentioned the use of the acid-etching technique as a crucial requisite for the effective bonding of the sealant to the tooth surface, the literature also states that the air abrasion technique performed before sealant application is equally fulfilling.[15] Thus, a comparative assessment between the two techniques, that is, air abrasion and acid-etching, needs to be performed to determine the retentive property of the sealants.

Despite the immense amount of research carried out to evaluate the efficacy of the acid-etching technique in enhancing the retention of sealants, the role of air abrasion is still a matter of debate. The fact that the air abrasion technique alone is sufficient enough for enhancing the retentive property of sealants is unclear. Systematic reviews, when performed, are intended to recognize, assess, and abridge the findings of all significant individual studies about a particular given topic, thereby making the evidence more accessible to researchers. There are many studies on the retention of sealants with diverse results. Therefore, this systematic review was designed to stipulate an extensive data pool concerning the air abrasion technique and its effect on the retentivity of the sealants in comparison to the acid-etching technique, which is lacking in the literature.

Materials and Methods

Registration and Protocol

The current systematic review was drafted according to the recommendations of the Preferred Reporting Items for Systematic Review and Meta-Analysis checklist and registered in Prospective Register of Systematic Reviews (CRD42021237783).

Eligibility Criteria

This study aimed to include randomized clinical trials (RCTs) that evaluated the effectiveness of the air abrasion technique and acid-etching technique used before the application of sealants to increase their retentivity. Randomized studies that used the air abrasion technique as an adjunct to the acid-etching technique were also considered. The clinical question to be answered is intended to summarize the clinical effectiveness of the air abrasion technique in enhancing the retention of sealants as an adjunct to or as compared to the traditional acid-etching technique in permanent molars of children (PICO question: population [P]—children in the age-group between 6 and 12 years; intervention [I]—air abrasion technique performed before placement of sealant or air abrasion technique performed along with the acid-etching technique before placement of sealant; comparison [C]—acid-etching performed before placement of sealant; outcome [O]—retentivity of sealants).

Articles were restricted to English language only, and case reports, laboratory studies, *in vitro* studies, case series, retrospective studies, animal studies, interviews, studies that are still under progress (unfinished), abstracts of scientific meetings, reviews, commentaries, books chapters, letters, and editorials were not included. Studies with outcomes involving shear bond strength, microleakage, etc., of the sealant after performing the air abrasion technique were excluded.

Sources of Data and Search Strategy

Randomized clinical trials performed between 1997 and 2019 were considered. The electronic searches were carried out from the databases' date of commencement until May 2019 in Medline through PubMed and the Cochrane Library. A search in the gray literature through Google was also performed. The keywords, along with their combinations used in the search strategies, were exclusive to each database (Table 1).

Selection of Studies

A two-phase selection process was carried out for the studies. Two reviewers independently selected the articles after the evaluation of both the titles and abstracts in phase one. In the case there was any disagreement between reviewers, a third reviewer was considered and consulted. Articles whose titles and/or abstracts met the criteria for eligibility were considered and included. Furthermore, articles whose titles/abstracts did not meet the criteria for inclusion were not considered. In case the abstract did not contain an adequate amount of information, the full text of the article was considered for assessment, which was considered to be phase two. Phase two comprised the evaluation of the articles by the full texts. This was again carried out by the same reviewers to consider their exclusion or intrusion. Those articles meeting the eligibility criteria were considered and included. In case of discrepancy among the two reviewers, we conferred a third reviewer.

Table 1: Search strategy for each database searched

Database	*Search strategy*	*Results*
Medline through PubMed	Air abrasion, dental OR dental air abrasion OR air abrasion OR enamel air abrasion OR air abrasion; enamel AND acid-etching, dental OR dental acid-etching OR acid-etching OR enamel etching OR dental etching AND pit and fissure sealant retentivity OR retention of pit and fissure sealant OR sealant retentivity OR sealant retention OR dental sealant retention	124
The Cochrane Library	Dental air abrasion AND dental acid-etching AND pit and fissure sealant retention	6
Google Scholar	Retention of pit and fissure sealants OR sealant retention OR pit and fissure sealant retentivity OR dental sealant retention AND acid-etching technique OR dental acid-etching OR enamel etching OR dental etching AND permanent first molars AND air abrasion OR dental air abrasion	276

Data Extraction

The data from the selected articles was extracted by two independent reviewers. Each of the reviewers prepared a customized table to collect the data. In case there were any disagreements again at this stage between the two reviewers, a third reviewer was conferred till unanimity was achieved. Following this, the extracted data from both tables were compiled into a single table. Subsequent data were extracted for the current review: title of the systematic review, author's name, name of the institute, year of publication, name of the country, ethical approval from the college, informed consent, study design, randomization method, control and comparator groups, age of the included patients in the study, details of inclusion and exclusion criteria, type of intervention obtained, type of sealant used, the brand name of pit and fissure sealant used, type of acid used for etching, the concentration of acid used for etching, time (chairside) required for performing air abrasion procedure, time (chairside) required for performing acid-etching procedure, exact sequence performed before placement of sealant in the study group, exact sequence performed before placement of sealant in the control group, recall or follow-up period, method used for checking the retentivity of sealant, type of instruments used for checking the retentivity of pit, and fissure sealant (if any).

Risk of Bias within Studies

The Cochrane Collaboration tool was used to determine the risk of bias in the included studies. The tool is framed into seven domains, which are as follows: (1) random sequence generation; (2) allocation concealment; (3) blinding of participants and personnel; (4) blinding of outcome assessor; (5) incomplete outcome data; (6) selective reporting; and (7) other sources of bias. The evaluated study for each domain was awarded one of the following outcomes: a low risk, a high risk, and an unclear risk of bias.

Results

Selection of the Studies

The preliminary search strategy yielded 276 results in total. Studies from Google Scholar were also included. Once the duplicated articles were recognized and removed, 128 articles were further evaluated. Lastly, after a meticulous and strict application of both criteria, seven articles[16–22] were selected for the review. The flow diagram for the search strategy of the systematic review is depicted in Flowchart 1. All the selected studies were RCTs.

Study Characteristics

The details of the seven studies considered in the current systematic review are given in the results of the individual studies. The participants considered in the study belonged to the age-group of 6–12 years. The most important adhered-to inclusion criterion was the presence of completely erupted permanent molars without any caries. The retention of sealants was assessed using conventional mouth mirrors and probe/explorers in all the studies. The major outcome assessed was retentivity of pit and fissure caries in all the included studies, although two studies also evaluated the cariostatic effect after postpit and fissure sealant placement, and one study even mentioned the chair side time required for both air abrasion and acid-etching techniques. Air abrasion technique alone was performed in the experimental group of five of the included studies, whereas two studies had their experimental group that conducted air abrasion technique followed by acid-etching technique. Details about these studies are given in Table 2.

Risk of Bias

Random sequence generation was adequately reported only in two out of seven studies (low risk). None of the studies mentioned blinding the participants or the investigator performing the treatment, as it was not possible to blind the participants and the operator to the interventions because

Flowchart 1: Flowchart of studies selection, retrieval, and inclusion

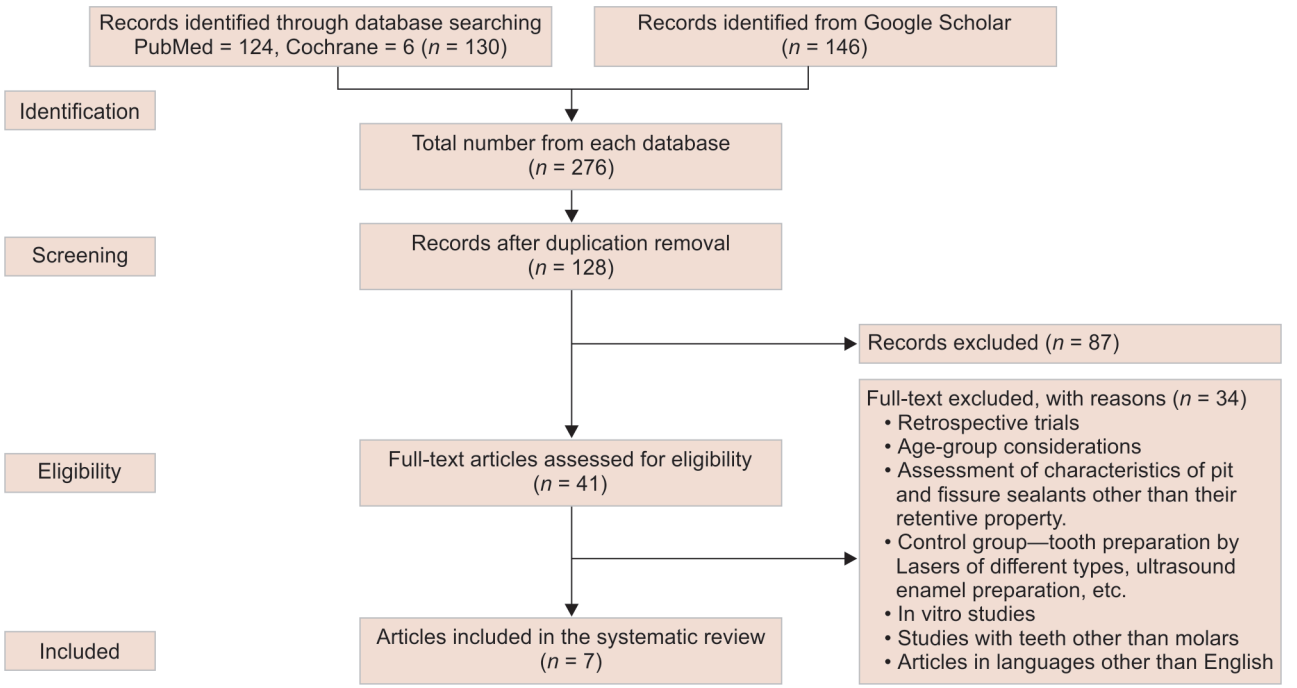


Table 2: Detailed chart related to the studies included in the systematic review

Serial no.	*Study, year, country*	*Study design*	*Method for evaluating the retentivity of sealant and criteria used*	*Intervention*	*Control/ comparator group*	*Conclusion*
1.	Bendinskaite et al. (2010); Lithuania	RCT	The subjects were examined under standardized conditions using a flat mirror and blunt exploration probe by a trained examiner; the condition of the occlusal surfaces of molars was evaluated using clinical visual assessment by the WHO criteria	Air abrasion system	Acid-etching technique	• The retention rate of sealants on the first permanent molars appears to be high within the 5-year period and whatever method is used: the enamel air abrasion and acid-etching. • The differences between results after applying the two methods regarding sealant retention and caries development were not statistically significant after 5 years ($p > 0.05$).
2.	Gani et al. (2019); India	RCT	Sealants were checked under visual examination; a CPI probe was used to assess the retention in a dental chair under the operatory light; the retention rate was assessed based on the color, coverage, and caries (CCC) sealant evaluation system described by Deery et al.	Air abrasion system	Acid-etching technique	• When acid-etching and air abrasion were compared to different sealant coverage categories of pit and fissure sealant at all intervals, a statistically insignificant difference was found. • Caries was found a little more in the air abrasion group, but a statistically insignificant difference was found when acid-etching and air abrasion groups were compared to caries at all the intervals. • It is suggested that to derive the full potential of caries prevention, sealants should be of optimal coverage. To achieve this, sealed surfaces require regular monitoring and appropriate maintenance.
3.	Kanellis et al. (1997); United States of America	RCT	Examinations were conducted using a portable dental chair, a headlamp, a mirror, and an explorer; sealants placed as part of this clinical trial were classified as either completely present, partially present, or completely missing, using criteria described by Simonsen; occlusal, distolingual, and buccal pit surfaces were scored separately; distolingual scores included the distal pit and lingual groove considered together as one surface.	Air abrasion system	Acid-etching technique	• 6-month retention rates of occlusal surface sealants were comparable for both techniques. • 6-month retention rates of distolingual and buccal pit surfaces were significantly lower for air abrasion sealants than for acid-etch sealants.
4.	Kanellis et al. (2000); United States of America	RCT	The follow-up examinations were conducted using a portable chair, headlamp, mirror, and explorer; sealants placed as part of this clinical trial were classified as either completely present, partially present, or completely missing, using criteria described by Simonsen	Air abrasion system	Acid-etching technique	It does not appear that air abrasion without acid-etching offers a significant advantage over traditional sealant placement methods and, in fact, appears to be inferior to the acid-etch technique for use in public health settings
5.	Reddy et al. (2014); India	RCT	Follow-up examinations were conducted using a dental chair, a headlamp, a mirror, and an explorer; sealants placed as part of this clinical trial were classified as either completely present, partially present, or completely missing, using criteria described by Simonsen; occlusal and buccal pit surfaces were scored separately	Air abrasion system	Acid-etching technique	Rates of complete retention on the occlusal and buccal surfaces of both treatment groups were not significant

Contd…

Contd…

Serial no.	*Study, year, country*	*Study design*	*Method for evaluating the retentivity of sealant and criteria used*	*Intervention*	*Control/ comparator group*	*Conclusion*
6.	Singh et al. (2019) India	RCT	The clinical evaluation of sealants was done with the aid of dental explorer no. 5 and intraoral mirror for partial or total loss of sealant and caries according to modified Simonsen's criteria	An air abrasion system was followed by an acid-etching technique, followed by the application of pit and fissure sealants in group I and flowable composite in group II	The acid-etching technique was only followed by the application of pit and fissure sealants in group III and flowable composite in group IV	• The flowable composite was relatively better retained than sealant at 12 months follow-up, although results are statistically insignificant. • Air abrasions followed by acid-etching brought superior retention than acid-etching. • Mandibular teeth have shown relatively superior retention.
7.	Bhushan and Goswami (2017) India	RCT	Examinations were conducted in a dental chair with the aid of a mouth mirror; the criteria used for evaluation were according to Simonsen's criteria	Air abrasion system followed by acid-etching technique	Acid-etching technique only	• When air abrasion pretreatment was carried out with subsequent acid-etching, there was no statistically significant difference seen in sealant retention when compared to the acid-etching technique performed alone in both primary and permanent molars after a follow-up period of 3 and 6 months. • Completely retained sealants were found to be more in the group. When air abrasion pretreatment was combined with an acid-etching technique, there the retentivity of sealants was seen to be better, but the difference was not statistically significant. • Retention of sealants in permanent molars was superior to primary molars, but the difference was not statistically significant. • Sealant retention was influenced according to tooth location, with maxillary molars showing better retention compared to mandibular molars, which was statistically significant. • Additional air abrasion pretreatment steps can be avoided in pediatric patients, and the procedure can be completed faster with better behavior management.

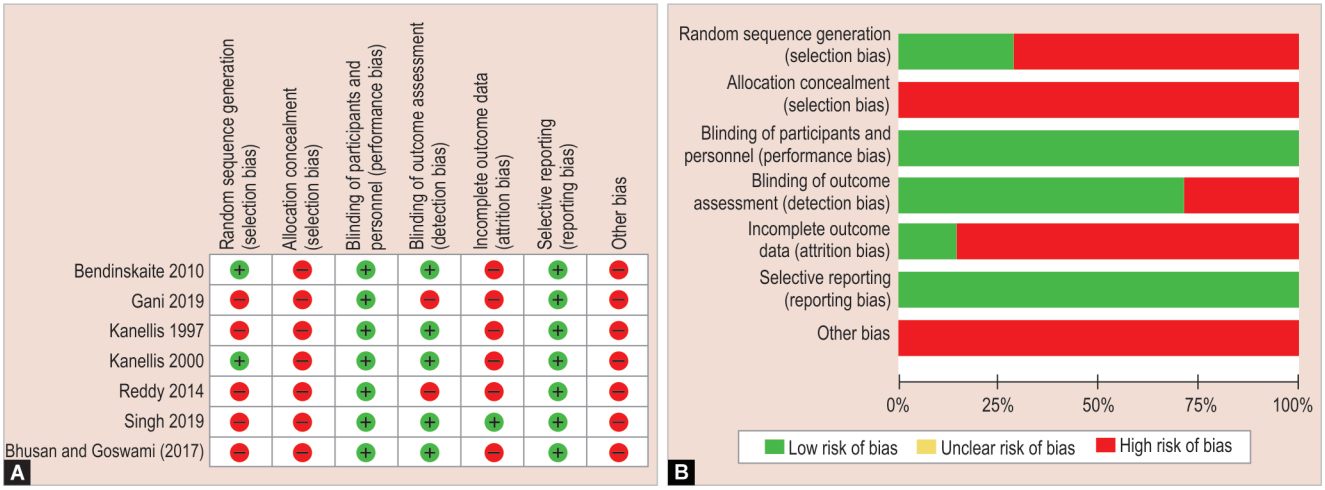
*RCT, randomized controlled trial

of the nature of the intervention. Six out of seven studies reported dropouts; however, none mentioned measures taken to recompense for missing data. One study was completed, and all the participants were evaluated at every interval. Selective reporting was primarily neglected in all the studies. The risk of bias assessment of the studies, based on the Cochrane tool, is shown in Figure 1.

A meta-analysis was unfeasible because the included articles were not homogeneous in their methodology. Also, comparisons between interventions could not be accomplished.

Discussion

It is a well-known fact that bacterial colonization in morphologically susceptible areas, such as occlusal surfaces of newly erupted molar teeth, can exacerbate demineralization, subsequently leading to carious lesions. Despite diligent oral hygiene practices, occlusal caries (pit and fissure caries in particular) are inescapable in most children and adolescents, accounting for the anatomy of the surfaces of the fissures and pits, which favors the torpor of the substrates and the bacteria. The extreme vulnerability of carious lesions, particularly concerning the occlusal surfaces, prompted



Figs 1A and B: Quality assessment of the study included based on the Cochrane collaboration tool

researchers in the field of dentistry to find out different ways to prevent caries, especially for pits and fissures. The result of these attempts led to advancement in preventive techniques, one of which includes the sealing of the occlusal surfaces. The caries-preventing characteristics of sealants are accredited to the blockade of the pits and fissures. Furthermore, it is a noninvasive technique and can be performed easily in apprehensive patients as well.

A review from Cochrane was published in 2013 stating that caries incidences were reduced up to 48 months in children and adolescents after the sealing of the pits and fissures of the permanent molars.[23] Likewise, sealants are precisely advised in children with high caries risk assessment and also in those with deep pits as well as fissures.

However, regardless of the immense popularity of the use of sealants in children, it has been evident that, as the follow-up prolongs, there was a relative decrease in the quantity as well as quality in terms of sealant retentivity. Several literature reviews in the past also stated that the clinical efficacy of dental sealants is majorly subjected to the retention of the sealant.[23,24]

Therefore, the retention of sealant after its application became the major focus of interest among the researchers. It was subsequently found that the most crucial requisite for retention is modification of the surfaces of the enamel, either with an acid conditioner or through mechanical means.

Apart from the traditional acid-etching technique and lasers, an additional method of enamel pretreatment, the air abrasive technique, also known as sandblasting, has been gaining recognition. Air abrasion technology utilizes a high-speed jet, usually comprised of Al_2O_3 particulates (50/90 µm), driven by air pressure.[25]

Although there are a few clinical studies mentioned in the literature comparing the retentive efficacy of sealants when air abrasion and acid-etching techniques were used as pretreatment procedures, no systematic review was compiled regarding the same. Considering this lacuna in the literature and helping the researchers avail to better-informed evidence concerning the role of air abrasion technique in increasing the retentivity of sealants, we were prompted to perform this systematic review.

The current systematic review considered seven RCTs to determine mainly the rates of retention and the incidence of secondary caries. However, an included study by Kanellis et al.[19] also additionally evaluated the chair-side time needed for the application of the sealant, with acid-etching and air abrasion technique individually as enamel pretreatment. Their results made it evident that the air abrasion technology considerably reduced chair-side time, and the method needed a lesser number of steps than the traditional methods. The air abrasion group needed only 7 minutes 36 seconds for the placement of the four sealants, whereas the time needed for the placement of sealants in four molars with the conventional acid-etch technique was 10 minutes 56 seconds. These findings showed similarity to those evaluated in a similar study conducted by Calderone and Mueller, who required around 9 minutes 25 seconds for the placement of sealants in four molars with the acid-etching technique.[26]

The Consequence of Study Methodology on the Outcome

Certain methodological disparities in the included studies are worth mentioning. The first is related to the outcomes of the current studies: the split-mouth design was applied in four out of the seven studies.[17,20–22] Split-mouth is considered to be a more appropriate design as, in this type, we can minimize the effects of inter-subject variation. Out of the four studies considering split-mouth design, three studies showed the random division of two groups on either half of the mouth, wherein the molars of one half underwent an acid-etching procedure, and the molars of the other half were treated with air abrasion technique. The fourth study by Singh et al.,[21] on the other hand, portrayed the division of four groups, wherein each first molar in all the four quadrants was treated using four different techniques—group I included the maxillary first molar of the right side and the tooth was treated with air abrasion followed by acid-etching technique, and then the sealant was placed. Group II included the first mandibular molar of the right side, and the tooth was treated with air abrasion followed by an acid-etching technique. Then, the placement of flowable composites was performed. Group III included the first mandibular molar of the left side, and the tooth was treated with acid-etching alone, followed by sealant placement. Group IV was treated with acid-etching alone, followed by the placement of flowable composites. The result of this multitechnique study stated that air abrasion followed by the acid-etching technique showed less sealant loss than the acid-etching technique alone. Furthermore,

it was also concluded that group II (composite placement with air abrasion) showed maximum retention (73.3%) compared to sealant placed with air abrasion group I (70%). Likewise, Aguilar et al., in their study, postulated that the retentive, as well as the penetrative property of a material, increases when it contains a higher percentage of filler when compared to conventional sealant.[27] The superior quality of retention of composites than the sealants can be attributed to the fact bagged by Oba et al. that filled resins have a lesser amount of polymerization shrinkage, higher viscosity, increased microhardness, and better resistance to abrasion than the conventional sealants.[21]

In the case of high-risk caries, the caries incidence rate and the retention rate are highly influenced. According to a study by Oulis and Berdouses, children with high caries risk showed lesser sealant retentivity. Further, a higher incidence of caries was evident in them, post sealant loss, when compared to children with moderate and low risk.[28] However, all the studies in our systematic review included only noncarious and nonrestored molars, thereby avoiding any bias occurring due to the changes in the structure of the tooth by carious involvement.

Yet another factor involving the retention of sealant includes the type and choice of tooth location. As the population for our review included only children from the age-group of 6–12 years, we have considered the first permanent molars as the tooth of interest. Although we could have included primary molars as well in our review, owing to the age-group in which the children belonged, we, unfortunately, couldn't come across studies involving primary teeth treated with air abrasion technique before pit and fissure placement, except for the one by Bhushan and Goswami,[22] which included primary second molars along with permanent first molars. The reason behind the difficulty of conducting clinical studies, especially on primary teeth, according to Naaman et al., included several confounding factors, such as age, cooperation, and behavior of the children with a comparatively younger age.[29] The study by Bhushan and Goswami[22] concluded that the sealant retentivity in permanent molars was higher than in primary molars; however, the difference was not statistically significant. The probable reasons might correlate to the facts stated by Naaman et al. stated above.

Considering the arch-specific retentivity, Bhushan and Goswami[22] stated that the property of sealant retentivity was also determined by the location of the tooth. The maxillary molars showed higher retention in comparison to mandibular molars. The difference furthermore was statistically significant. This was in accordance with the results by Handelman et al.,[30] who postulated that maxillary premolars showed approximately a 5% higher sealant retention rate than mandibular premolars in their study. Considering the type of teeth involved, all our studies[16–22] included only molar teeth. However, Papageorgiou et al., in their systematic review and meta-analysis, stated that the premolars had better sealant retentivity rates than the first permanent molars.[31] They further stated that this was attributed to factors such as the isolation obtained, the accessibility to the surface of the tooth, and discrepancies in the microscopical and morphological structure of the enamel of both teeth.

Air Abrasion Combined with Acid-etching Technique

In our review, two of the studies, Singh et al.[21] and Bhushan and Goswami[22] compared the sealant retentivity property using air abrasion technique followed by acid-etching and acid-etching alone. Results from the study by Bhushan and Goswami[22] concluded that combining air abrasion treatment followed by acid-etching did not result in a statistically significant difference in sealant retention when compared to acid-etching alone. On the contrary, the results of Singh et al.[21] postulated that air abrasion followed by acid-etching brought superior retention than acid-etching alone.

Taking into consideration the constrained evidence in the existing studies, more clinical research is needed to validate the role of air abrasion in pit-and-fissure sealants in the future.

Conclusion

When coverage of sealants or their retentivity was compared at different time intervals, it was more in the acid-etching group than in the air abrasion group. However, the differences between results after applying the two methods were not statistically significant. Similarly, carious lesions were seen more in the air abrasion group than in the acid-etching group, but the statistical difference found was insignificant at all the intervals. Air abrasion followed by acid-etching brought superior retention than acid-etching alone. However, the data obtained was relatively insignificant, and we can thus infer that an additional air abrasion pretreatment step can be avoided to complete the procedure faster.

There are very limited studies performed on sealant retention in primary teeth. Hence, more research should be done comparing primary and permanent teeth to find out the impact of morphological differences (as primary molars have shallow pits and fissures) and histological differences on the retentivity of pit and fissure sealants. Likewise, more specific and well-designed randomized control trials to evaluate the retentivity of pit and fissure sealants postair abrasion treatment should be carried out to obtain significant results and conclusions.

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