Air-Abrasive Technology for Caries Diagnosis and Fissure Sealing. A Clinical Study

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Abstract

Aim: The aim of this study was to evaluate the suitability of air-abrasive technology for fissure caries diagnosis and conditioning the occlusal tooth surface before sealing. ***Methods:*** Eighteen patients (age range 6-15 years) with 66 permanent molars with darkened fissures were examined for caries by visual inspection (VI), laser fluorescence (LF), and air abrasion (AA). AA was used as a reference. If there were no clinical signs of dentinal lesions after AA, occlusal surfaces were sealed. VI and LF were assessed for sensitivity and specificity. The patients were asked about the level of acceptability of AA. Six months later, sealed teeth were re-examined applying modified United States Public Health System (USPHS) criteria for retention of the sealer. ***Results:*** VI showed a sensitivity of 60% and LF of 90% in relation to the reference. The specificity of VI was 98%, whereas LF had a specificity of 75%. Of the 66 teeth examined, 56 did not show any dentinal caries and could be sealed; the remaining 10 were filled. Sixty-three (95%) of the patients rated AA as good or very good. After six months, the maintenance of the sealer could be assured in 44 teeth (83%). ***Conclusions:*** It can be concluded that current caries detection methods can be complemented by AA, which is also useful for conditioning the occlusal surfaces before sealing in paediatric dentistry. AA roughens the occlusal surface and optimises retention of the sealer. However, a small risk remains because of overcutting of sound tissue or arresting initial lesions.

Key Words: Air-Abrasive Technology, Caries Diagnosis, Fissure Sealing, Paediatric Dentistry

Introduction

The high availability of fluoride, and the establishment and realisation of prevention concepts in industrial nations have led to a change in the epidemiology of oral diseases, in general, and dental caries, in particular. There has been a general decline in the prevalence of caries in children and an increase in the number of children with caries-free teeth [1]. Accompanying this trend, a caries polarisation has been observed: this means that there is an unequal distribution of caries in the child population in many countries [2]. Nevertheless, numerous epidemiological data and clinical experience have repeatedly shown that occlusal surfaces of permanent molars are still the most vulnerable sites for dental caries [3]. The most important reason for this is the surface-specific anatomy along with plaque accumulation *(Figure 1).* The toothbrush cannot clean the depths of fissures effectively and after lengthy plaque retention an occlusal lesion appears. Furthermore, enamel in the fissure region is very thin in comparison with other surfaces and the effect of fluoride is minimised [3-6]. Fissure sealing has been shown to be an evidence-based caries preventive method for protecting the occlusal surfaces against caries [7,8]. Before fissure sealing, accurate lesion detection is essential and this is more difficult today because of so-called "hidden caries". Detection almost always starts with visual inspection systems, which enable the identification of early carious lesions and their levels of activity [9]. Visual inspection should be complemented by advanced methods for the detection and quantification of caries lesions. The DIAGNOdent instrument (KaVo, Biberach, Germany) was introduced as an adjunct to visual

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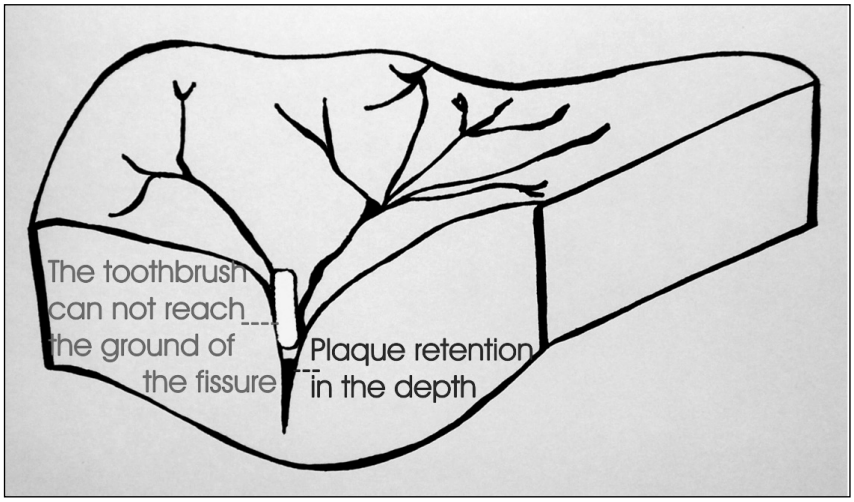

Figure 1. *Schematic demonstration of plaque retention in the depth of fissure.*

inspection in 1998. It has been proved to be a valuable tool in experimental and clinical studies [10,11]. It is based on fluorescent light measurement with a wavelength of 655 nm (red light). The reflected intensity of this light is an indicator of the size and depth of caries lesions. Bitewing radiographs are also practical for the detection of occlusal lesions [12-14].

Recently, air-abrasive technology has experienced a rebirth in dentistry as a result of improvements in adhesive material development and the philosophy of minimally invasive restorative treatment. Originally developed in the late 1940s [15-17] for removing dental caries, the current models of air abrasion units introduced in the last decade provide a new approach to diagnosing pit and fissure caries [18,19]. Instruments used for air-abrasive technology work with abrasive powder (microfine aluminium oxide) in combination with water-jet and air pressure. The powder particles gain kinetic energy for cleaning and roughening the occlusal surface. The rediscovered air-abrasive methodology has the clinical ability to eliminate both stains and organic debris quickly and to permit the detection of dental caries in its earliest stages. A further indication for the application of air-abrasive tools is conditioning of the roughened enamel of occlusal tooth surfaces prior to fissure sealing. Of course, air abrasion cannot replace the normal conditioning of the enamel by acid-etching but, according to the literature [20,21], the most successful method was air abrasion in combination with acid-etching, which leads to better sealer retention. Air-abrasive instruments allow the procedures to be performed without pain, vibration, and annoying sounds. They are especially recommended for the use in paediatric dentistry [22,23]. However, no clinical studies exist about the efficacy of the latest air-abrasion tool, Air-Flow® Prep K1 Max.

Aims

The objective of this clinical study was to evaluate the suitability of air-abrasive technology by using Air-Flow® Prep K1 Max in paediatric dentistry for the confirmation of a diagnosis of occlusal caries diagnosis, as well as for conditioning the enamel surface before fissure sealing.

Methods

The study started with the selection of patients from the department of paediatric dentistry at the Friedrich Schiller University, Jena, Germany, within a three-month period. Subjects were required to have at least one permanent molar with a questionable incipient occlusal carious lesion and no respiratory problems, as well as a clear airway. During the time span, 18 patients (male: n=11, 61.1%; female: n=7, 38.9%) met the criteria for inclusion in the clinical trial. This sample size was regarded as suitable for this study. The mean age of the patients was 10.7 years (range: 6-15 years). Before the trial, patients and their parents were informed about the procedures and informed consent was obtained. The study was approved by the relevant ethical committee of the University of Jena.

Clinical examination was based on different caries detection methods to exclude dentinal caries in occlusal surfaces, which is contra-indicated for fissure sealing. Sixty-six permanent molars were examined by visual inspection (VI) [24], followed by laser fluorescence (LF) (DIAGNOdent, KaVo, Biberach, Germany) *(Figure 2),* and inspection

after using air-abrasive technology (AA). Air-Flow® Prep K1 Max (Electro Medical Systems [EMS], Switzerland) was used for air abrasion and as a reference for caries diagnosis. This instrument *(Figure 3)* interfaced with the dental unit (KaVo Estetica 1065). It produces its effect through powder (aluminium oxide particles, diameter 27 micrometer), a water jet and air pressure, which provide the powder particles with kinetic energy for cleaning and roughening the occlusal tooth surface. If there were no clinical signs of dentinal caries after using AA, the fissures were sealed with Fissurit Fx (VOCO, Germany), following German guidelines for fissure sealing [8]. Molars with dentinal caries were filled. Each child completed a questionnaire to assess the level of acceptance of the AA technique.

Figure 2. *DIAGNOdent (KaVo, Germany).*

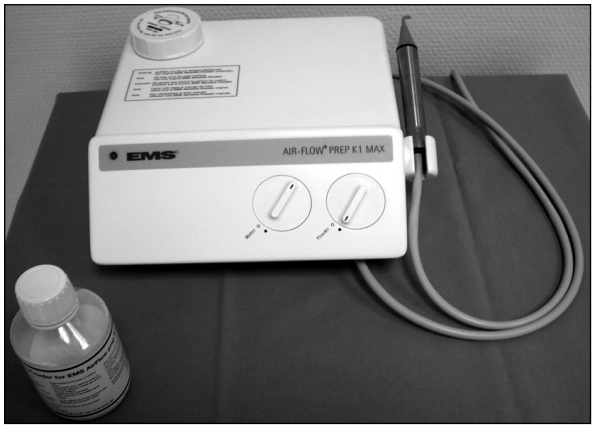

Figure 3. *Air-Flow® Prep K1 Max (EMS, Switzerland).*

Six months later, children were re-examined visually for the retention of the sealer using the USPHS criteria [25], which were adapted to the sealant assessment for this study *(Table 1).* All data were registered in an examination protocol.

Table 1. *Criteria for Retention of Fissure Sealing (Kouzmina 2009 [26])*

Alpha	Total retention
Bravo	Partial retention
Charlie	No retention

Data analysis

After entering clinical and questionnaire data into statistical software (SPSS version 15; SPSS Inc., Chicago, U.S.A.), the sensitivity and specificity of VI and LF in relation to the reference were calculated. Sealant retention at follow-up was calculated as percentages in the three categories identified by Kouzmina *et al.* (2009) [26] *(Table 1).*

Results

Fifty-two (78.8%) first permanent molars and 14 (21.2%) second permanent molars were examined. The number of teeth that were identified with carious dentine varied between the different caries-detection methods. With VI, the occlusal surfaces of seven (10.7%) teeth could be identified as having a dentinal lesion. By using LF method, the occlusal surfaces of 23 (34.9%) teeth showed caries in dentine. In contrast to these results, the reference method (AA) detected dentinal caries in the occlusal surfaces of ten (15.2%) teeth *(Figure 4),* thus ten teeth were deemed to require filling. The occlusal surfaces of the remaining 56 (84.8%) molars were free of dentinal caries lesions and could subsequently be sealed. The accuracy of the applied diagnostic methods represented 92.4% for VI and 77.3% for LF according to the chosen reference method (AA). The validity showed a sensitivity of 60% for VI and of 90% for LF whereas the specificity of VI was 98% and 75% for LF *(Table 2).*

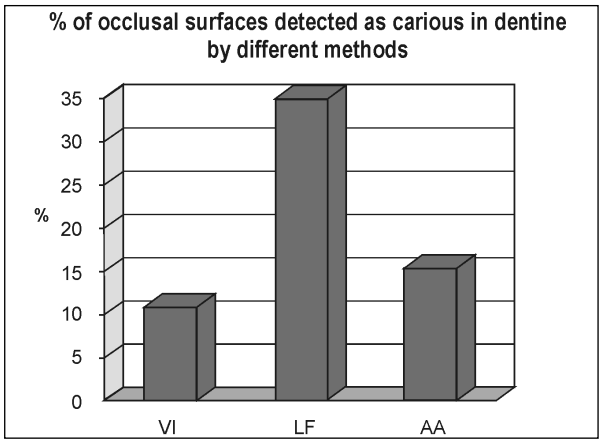

Figure 4. *Percentages of occlusal surfaces detected as carious in dentine by different methods.*

Table 2. *Sensitivity and Specificity of Visual Inspection (VI) and Laserfluorescence (LF)*

Caries detection method	Sensitivity (%)	Specificity (%)
Visual inspection (VI)	60.0	98.2
Laserfluorescence (LF)	90.0	75.0

The results of the questionnaire revealed that seven (38%) of the children rated the air-abrasive technology as acceptable and ten (57%) as very acceptable. Only one patient (5%) did not accept the treatment with AA *(Figure 5).*

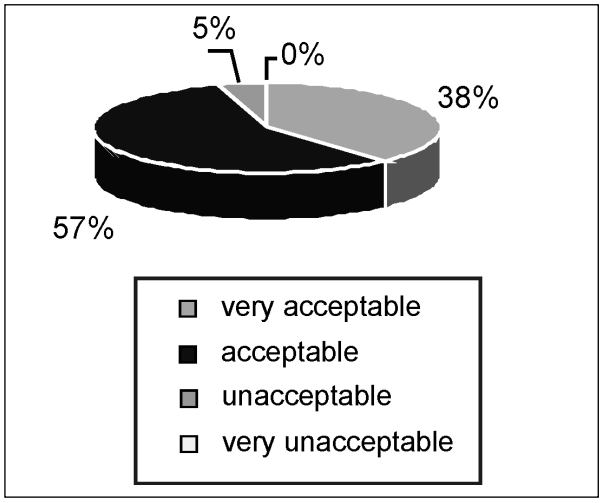

Figure 5. *Subjects' rating about the treatment with air abrasion.*

After six months, 16 patients with 53 sealed teeth could be re-examined. Two patients with three sealed teeth were not available for a re-examination due to changing their residence. Complete retention of the sealer was seen in 83% (44 teeth) of re-examined molars (Alpha) and 17% (9 teeth) of the sealed fissures showed a partial loss of sealing material (Bravo). There was no total loss of sealing material (Charlie) *(Figure 6).*

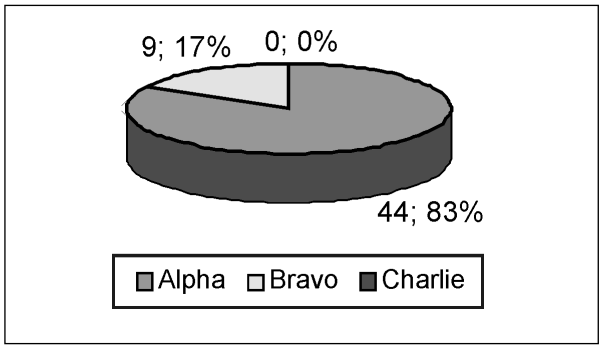

Figure 6. *Retention of the sealing material after six months.*

Discussion

Dental caries continues to provide a very sizeable burden of preventable disease on a global scale [27]. The trends in clinical caries management are based on a discrimination between those lesions for which preventive care is advised and those that are suitable for operative intervention [28]. The realisation of clinical caries management suggests the need for a new emphasis on diagnosing, preventing, and treating caries lesions. This is especially important at occlusal surfaces of permanent molars, which represent the most vulnerable tooth surfaces. Studies on diagnosis suggest that careful visual inspection of an air-dried tooth surface is most reliable [29,30]. In the past, a number of comprehensive diagnostic tools and methodologies have been developed to improve caries detection, especially for very early lesions. The air-abrasion technique provides an alternative to current detection methods.

Two of the most valid caries diagnostic methods, visual inspection and the laser fluorescence technique, were applied in this study for comparing their suitability with the air-abrasive technique. With regard to accuracy, all tested detection methods showed good or very good results in terms of their validity (as measured by specificity and sensitivity). According to one study [31], detection methods can be recommended for caries prediction if the sum of sensitivity and specificity is higher than 160%. However, VI revealed higher values than LF in comparison to the reference, thus VI should be considered as first choice in the caries detection process. The results of this study demonstrated the diagnostic value of AA and it should be recognised as a valid tool to complement current caries-detection methods. Previously, only a few studies have been reported which used air-abrasive technique for caries diagnosis [18,19,32]. The results of this study confirm their findings. Air abrasion cleans the occlusal surface by leaving all but a few microns of healthy tooth structure intact. It roughens the enamel surface and optimises retention of the sealing material [20,21]. In this study, there was a high retention rate of the fissure sealants (more than 80% after six months). This result is in concordance with previous studies and was based on the dual action of mechanical (AA) and chemical (acid etching) conditioning [20,21].

Dentists wishing to work with air-abrasive devices should take into account special recommendations, previously described by Goldstein and

Parkins [18,19], otherwise an overcutting of hard tissues will result. These recommendations concern, for example, air pressure, distance from attachment piece to tooth surface, and powder–water ratio. To avoid overtreatment, the nozzle of the AA instrument should be not more than 3 mm distant from the tooth surface. For caries diagnosis, the clinician must either reduce the amount of powder that is expressed or reduce the air pressure, as in the current study. Also, the powder-, water- and air-pressure jet should reach the occlusal surface at a defined angle (45 degrees).

It was pleasing to note that the majority of participants in this study rated the treatment with AA very positively, above all because the treatment was painless.

The results of this study are comparable with those from other studies [17,23,33]; however, they should be treated with some caution because only 18 children took part and the follow-up period was only for six months.

Conclusions

The air-abrasive technique has different applications in dentistry. In the small group of children in this study, the Air-Flow Prep K1 Max proved successful for caries diagnosis as well as for conditioning occlusal surfaces before fissure sealing. Although it can be recommended for paediatric dentistry, it should always be used carefully because there is a small risk of overcutting sound tissue.

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