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PITS AND FISSURE SEALING

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ГЕРМЕТИЗАЦИЯ ЯМОК И ФИССУР

PITS AND FISSURE SEALING

Учебно-методическое пособие

Минск БГМУ 2021

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Изложены основные сведения об особенностях профилактики кариеса наиболее частой локализации — в ямках и фиссурах зубов. Превентивная стратегия и тактика описаны в соответствии с факторами риска, патогенезом, клиникой и возможностями диагностики скрытого фиссурного кариеса. Значительное внимание уделено технологии герметизации ямок и фиссур. Представлены концепции терапевтической герметизациии и профилактической реставрации.

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INTRODUCTION

Oral health is an important part of overall health in children as well as adults. Dental caries is more prevalent in children and it could be because of eating patterns and lack of hygiene maintenance.

Over the last two decades, the prevalence of the dental caries on the smooth surfaces has declined but an increase of the proportion of caries on the occlusal surfaces has been found. The occlusal surface occupies 12.5 % of the total areas of teeth. Fissure caries accounts for 50 % of all the carious lesions.

Traditionally, occlusal surfaces are regarded as susceptible to dental caries as a result of their incomplete posteruptive maturation, i.e. their reduced mineral content in the enamel, and due to their morphology. Unfavorable morphology makes these fissures difficult for salivary access and minimizes fluoride deposition for preventive effect.

The most influential biological determinants for caries development and arrest on occlusal surfaces are thick plaque accumulation in the narrow and deep fissures on the occlusal surfaces and the stage of tooth eruption. The period of tooth eruption is considered a risk factor for caries development because occlusal surfaces offer good conditions for plaque accumulation and further caries development in this period due to their limited mechanical function.

Pit and fissure areas on the occlusal surface of the teeth make them susceptible to dental caries, which need to be prevented or restored. Fluorides and other caries preventive approaches (e.g., mechanical plaque control) seem to be less effective for preventing carious lesions in pit and fissure surfaces compared with smooth surfaces. However, occlusal caries may be controlled by nonoperative measures if such measures are implemented from the very beginning of tooth eruption and maintained until the tooth is in full occlusion.

Pit and fissure sealant is a material that is introduced into the occlusal pits and fissures of caries-susceptible teeth, thus forming a micromechanically bonded protective layer cutting access of caries-producing bacteria from their source of nutrients. Plentiful clinical studies have documented the efficacy of pit and fissure sealants in caries prevention.

Today, there are multiple commercially available materials for sealing, including resin-based sealants, such as urethane dimethacrylate or bisphenol A-glycidyl methacrylate monomers that are polymerized by means of either a chemical activation-initiation or a light activation system. Glass ionomer cements are another type of sealant material that have been widely recognized and used for their fluoride-release properties. State-of-the-art measures to control occlusal caries progression should be implemented from the very beginning of tooth eruption.

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EPIDEMIOLOGY OF PIT AND FISSURE CARIES

Structure of caries and restored tooth surfaces varies significantly in both the permanent and the primary dentitions. In a toothbrushing population, caries susceptibility in the permanent dentition may be ranked in the following order:

– fissures of the molars;

– mesial and distal surfaces of the first molars;

– mesial surfaces of the second molars and distal surfaces of the second premolars;

– distal and mesial surfaces of the maxillary first premolars and mesial surfaces of maxillary second premolars;

– distal surfaces of the canines and mesial surfaces of the mandibular first premolars;

– approximal surfaces of the maxillary incisors.

In nontoothbrushing populations, or in individuals with poor and irregular oral hygiene habits and a high intake of sticky sugary food, cervical lesions may also develop on the buccal surfaces of the maxillary teeth and on the mandibular molars and premolars.

Data on the decline of caries prevalence among children and young adults in most industrialized countries over the last two decades shows a relative increase in the proportion of caries on the occlusal surfaces of the permanent molars. Even in developing countries with relatively low caries prevalence, the occlusal surfaces of the permanent molars are carious more frequently than are the approximal surfaces.

The occlusal surface occupies 12.5 % of the total areas of teeth. According to the recent data, the relative proportion of pit and fissure lesions has increased to 80 percent of the total new caries experience. This is the first important change in the epidemiology of dental caries.

So, 3-year-olds children have 76 % of caries lesions in the pits and fissures and 85 % of all cavities are localized on occlusal surfaces of molars in 17-year-old adolescents.

Active prevention of caries determines the second important change in the epidemiology of caries of pits and fissures of teeth — polarization of distribution the carious disease in the population: 80 % of the lesions are concentrated in 20 % of the population.

On the basis of epidemiological, clinical and microbiological studies molars have been recognized as teeth with a high risk of dental caries and occlusal surfaces as surfaces with a high risk of caries. The initiation and development of occlusal caries is strongly correlated to the *morphology, eruption stage, and functional wear of the occlusal surface*.

MORPHOLOGY OF THE OCCLUSAL SURFACES OF THE MOLARS

Bacterial plaque is the essential precursor of caries. Hence, sites on the tooth surface which encourage plaque retention and stagnation are particularly prone to progression of lesions. These sites are:

– enamel in pits and fissures on occlusal surfaces of molars and premolars;
– buccal pits of molars;
– palatal pits of maxillary incisors.

Fissures and pits are more prone to the caries development than smooth surfaces due to the morphological complexity of these surfaces.

Viewed in a stereomicroscope, the occlusal surface of a permanent molar appears as a convoluted landscape, with high mountains (cusps) separated by valleys, some of which are deep rifts (fissures), while others resemble open river beds (grooves and fossae). The groove-fossa system is defined as the system that connects every single groove and fossa on the occlusal surface. A “fossa” is a depression on an occlusal surface where two or more grooves meet. An “interlobal groove” is a groove located between two or more lobes. An “intersegmental groove” is a groove located between two lobe segments. Together, the fossae and the interlobal and intersegmental grooves are referred to as “anatomical sites” of the groove-fossa system. Interlobal grooves with structure angles equal to or less than 25° are considered as having a fissure-like morphology.

There are three more or less distinct and deep fossae in the molars — a mesial, a central, and a distal fossa — and five to seven related fissures and grooves.

Fissure pattern and its relation to structure within the depth of enamel is highly variable and usually is between 0.25 and 3.0 mm. Its width varies from 0.005 till 1.5 mm at top (orifice), and from 0.1 till 1.2 mm at the base (bottom). In cross section, most fissures have a wide opening, followed by a narrow cleft, approximately 1.0 mm deep (width: 0.1 mm) and reaching almost to the dentinoenamel junction. However, there are some (less than 10 %) atypical fissures with a narrow opening and a bulbous widening at the base. Such fissures are regarded as sticky risk fissures.

Nagano classified occlusal fissure into five types on the basis of fissure morphology: V, U, Y, I, IK types (Fig. 1).

Pit and fissures are classified as self-cleansable (V and U types) and nonself-cleansable (I and k types).

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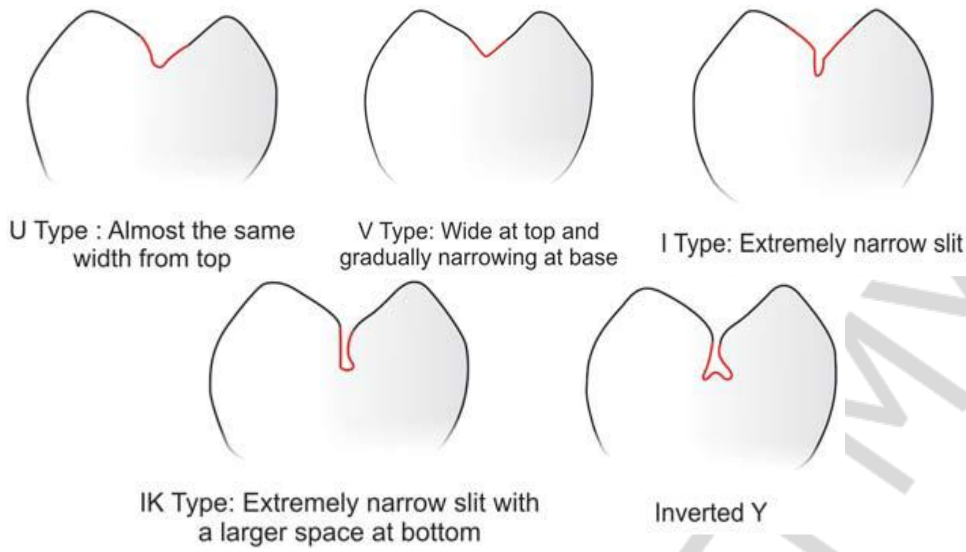

Figure 1. Types of fissures

Role of tooth-specific anatomy. Fissure caries is partly attributable to the extremely plaque-retentive morphology of the fissure systems.

It is a common clinical observation that caries on occlusal surfaces does not involve the entire fissure system with the same intensity, but rather is a localized occurrence. Each tooth type in the dentition has its own specific occlusal surface anatomy, and caries is usually detected in relation to the same specific anatomic configuration in identical tooth types. In maxillary molars, for example, the central and distal fossae are sites that typically accumulate plaque and hence are also the sites at which caries most often occurs. Most clinical and scientific concern with respect to occlusal caries has been over the possible events in deep and inaccessible fissures. However, caries always starts in the surface enamel as a result of the metabolic activity of bacterial accumulations on the surface. In general, occlusal caries is initiated at sites where bacterial accumulations are well protected against functional wear.

Progressive destruction of the occlusal surface begins as a local process in the groove-fossa system, as a result of accumulation of bacterial plaque. In this area, which is already sheltered from physical wear, the formation of a microcavity further improves the potential for bacterial attachment and colonization. This accelerates demineralization and destruction, enhancing local conditions for bacterial growth.

Role of eruption stage. It has been estimated that about five times more plaque will reaccumulate on the occlusal surfaces of erupting molars compared to fully erupted molars with full occlusion and functional wear function 48 hours after professional mechanical toothcleaning (PMTC). Most plaque reaccumulates in the distal and central fossae and related fissures. That is the reason why occlusal caries is initiated in molars during the extremely long period of eruption (12 to 18 months) and why the occlusal surfaces of the premolars, which have only a 1- to 2-month eruption time, rarely are carious. Development of caries in molars occurs, on average, within 11 months from the start of eruption, i.e., during eruption (most is decayed within 3 to 9 months).

It has been found a clear trend indicating that microbial growth conditions on occlusal surfaces were related to the degree in which the individual tooth was participating in oral function (Fig. 2).

Figure 2. Established plaque on erupting permanent first molar (*a*). The limited mechanical oral function of the erupting tooth offers good conditions for plaque accumulation and further development of active noncavitated occlusal caries lesions in the groove-fossa system (*b*)

The period of tooth eruption is considered a risk factor for caries development because occlusal surfaces offer good conditions for plaque accumulation and further caries development in this period due to their limited mechanical oral function[1]. However, occlusal caries may be controlled by nonoperative measures if such measures are implemented from the very beginning of tooth eruption and maintained until the tooth is in full occlusion. State-of-the-art measures to control occlusal caries progression should be implemented from the very beginning of tooth eruption.

In conclusion, two factors have been considered of importance for plaque accumulation and caries initiation on occlusal surfaces: 1) stage of eruption or functional usage of teeth; 2) tooth-specific anatomy.

Additionally, the following factors should be taken into considerations: the mineralization level of the enamel pits and fissures in newly erupted immature teeth and the adhesion conditions for cariogenic microorganisms.

Pre-eruptive mineralization of enamel pits and fissures. Immediately after the eruption, enamel of pits and fissures has a relatively low level of mineralization. The most intensively posteruptive mineralization of enamel on

[1] Partly erupted teeth accumulated significantly higher amounts of plaque than fully erupted teeth ($p < 0.001$). Distribution and accumulation of dental plaque on occlusal surfaces is highly related to tooth-specific occlusal macromorphology. The locations of these caries lesions were mapped on morphology cards. Location and activity of caries lesions were highly correlated with occlusal plaque distribution and accumulation, which was in turn determined by mechanical function ($p < 0.010$). On this basis, the influence of oral mechanical forces on occlusal plaque formation and caries development was verified.

the occlusal surface of molars occurs during the first two years after tooth eruption, the final maturation takes about 4–5 years.

Enamel in fissures matures slowly. The rate of maturation depends on the remineralizing properties of saliva and opportunities to contact with the surface of the enamel in the fissure. The degree of penetration of saliva into the depths of the fissure (Z) is determined by capillary forces and depends on the width of the fissures (S), surface tension of liquid (γ), contact angle (Θ), liquid viscosity (η) and time (t).

$$1{,}5Z = \frac{S\gamma \cos\theta}{6\eta} t$$

Therefore, enamel in open wide fissure has a good opportunity to get minerals from the saliva, but enamel in narrow deep fissure remains at low level of mineralization.

Rationale for the Concept of Incomplete Posteruptive Maturation. The concept of immature teeth is based, on the one hand, on the observation that porosity has been identified in the enamel of erupting teeth and, on the other hand, on the fact that an increased fluoride concentration has been identified in surface enamel after eruption. This observation suggested by analogy that enamel undergoes a period of posteruptive maturation following tooth eruption. During the eruption period, the enamel surface is undergoing several cycles of de- and remineralization, and fluoride present in the oral environment is leading to a gradual increase in fluoride in the outermost part of the surface enamel. When the enamel is exposed to low concentrations of ionic fluoride in an acid environment, fluorapatite is formed and deposited as part of the enamel tissue. It should, however, be appreciated that the overall substitution of hydroxyl ions by fluoride on surface enamel is limited, and that fluoride in the enamel plays a minor role in caries reduction.

Adhesion of the cariogenic microorganisms in the pits and fissures. For dental plaque to be cariogenic, i.e. to produce quantities of organic acids sufficient to dissolve the enamel, a protected environment is needed. In the oral cavity, protected environments are found in the so-called “stagnation areas” such as the cervical third of smooth and interproximal surfaces as well as on occlusal surfaces. These stagnation areas are protected from mechanical oral function, which comprises mastication and muscular movements of the tongue, lips and cheeks as well as those involved in the swallowing reflex. On occlusal surfaces, most attention is devoted to stagnation of dental biofilm in fissure-like structures and the possible events taking place in their deepest part.

If the formation of the microbial plaque on smooth enamel surfaces requires special adhesive properties of Streptococcus mutans, the plaque in the fissure can be created even by non-adherent microorganisms such as L. acidophilus, L. casei, A. viscosus, A. naeslundii, A. israeli, S. salivarius, S. sanguis, etc.

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DEVELOPMENT OF OCCLUSAL CARIES

It is a common clinical observation that caries on occlusal surfaces does not involve the entire fissure system with the same intensity, but rather is a localized occurrence. Each tooth type in the dentition has its own specific occlusal surface anatomy, and caries is usually detected in relation to the same specific anatomic configuration in identical tooth types. In maxillary molars, for example, the central and distal fossae are sites that typically accumulate plaque and hence are also the sites at which caries most often occurs. In general, occlusal caries is initiated at sites where bacterial accumulations are well protected against functional wear.

Pathogenesis of occlusal caries. Carious lesion starts at both sides of the fissure, not at the base. The enamel is thin in fissures so there is early dentine involvement. The carious lesion forms a triangular or cone shaped lesion with its apex at the outer surface and base towards the dentinoenamel junction (DEJ).

- Pit and fissures are often deep, with food stagnation.
- Lesion begins beneath plaque, with decalcification of enamel.
- Enamel in the bottom of pit or fissure is very thin, so early dentine involvement frequently occurs.
- Here the caries follows the direction of the enamel rods. In pit and fissure the enamel rods are said to flare laterally at the bottom of the pit and caries is said to follow the path of enamel rods hence a characteristic angular/inverted “V” shaped lesion is formed.
- It is triangular in shape with the apex facing the surface of tooth and the base towards the DEJ.
- When reaches DEJ, greater number of dentinal tubules are involved.
- It produces greater cavitation than the smooth surface caries and there is more undermining of enamel.

As enamel destruction proceeds, a true cavity forms, the outline reflecting the arrangement of rods in the areas. The cavity has the shape of a truncated cone. The particular anatomic configuration of the occlusal surface at the site of caries initiation explains why the opening of occlusal cavities is always smaller than the base. The dosed nature of the process obviously favors undisturbed growth of bacteria and hence accelerated destruction of the tissue. Occlusal enamel breakdown is the result of further demineralization from an initially established focus, rather than general demineralization involving the entire fissure system.

DIAGNOSIS OF OCCLUSAL CARIES

If intensified plaque control (self-care and need-related intervals of PMTC), topical use of fluorides, and needs-related use of fluoride-releasing glass-ionomer sealants keep the occlusal surfaces of the molars caries free during eruption (12 to 18 months), until they have reached full occlusion and normal functional wear, future occlusal caries diagnostic problems are solved. That is because the risk for development of cavitated caries lesions is over.

However, in new patients with fully erupted molars — for example, first molars in 8- to 11-year-old children, second molars in 14- to 16-year-old children, and third molars in young adults and adults the occlusal surfaces may already be carious into the dentin with or without cavitation and thus offer delicate differential diagnostic problems.

It might be expected that occlusal caries lesions would be fairly easy to diagnose because, unlike approximal and subgingival root surfaces, these surfaces are readily accessible for visual inspection.

However, clinically (visual or visual-tactile by probing) or radiographically, diagnosis of occlusal lesions is a delicate problem because of the complicated three-dimensional shape of the occlusal surfaces, which incorporate fossae and grooves with a great range of individual variations.

To date, the diagnostic threshold has been determined by the detection limits inherent in traditional diagnostic methods.

Today, the low prevalence of dental caries is observed in many countries. The fluoride prevention has had a delaying effect on the onset of the fissural caries and has contributed to the change of dental decay pattern and clinical behavior. Consequently, the caries lesions are smaller, especially in children, making their diagnosis more difficult. Diagnosis of precavitary lesions of occlusal surfaces is difficult.

Changes in caries presentation patterns have led to researchers' added interest in obtaining more refined diagnostic tools, which can detect caries lesions before they become visible to the naked eye and to the necessary creation or use of reliable diagnostic methods that avoid the generation of false positives or negatives, which lead to diagnostic error.

Therefore, diagnosis of occlusal caries should be simple if the occlusal surfaces were maintained free of caries until the surfaces reached full occlusal and functional wear by the efficient preventive measures.

However, in new patients with fully erupted molars, the occlusal surfaces may already be carious into the dentin with or without cavitation and thus offer delicate differential diagnostic problems.

A major consideration is that the diagnostic method should be reproducible given that otherwise, the long-term monitoring of lesions would be ruled out. In addition to caries diagnosis, it is essential to quantify the lesion, both for clinical decision-making and to monitor lesions to gauge their progress over time.

Several classic methods (visual examination, probe, bitewing radiographs) and new methods of diagnosis (magnification, digital radiographs, electronic, fibre-optic transillumination, CO_2 laser, ultrasound imaging) have been proposed both alone and in combination.

METHODS FOR FISSURE CARIES DETECTION

The most common methods for diagnosis of occlusal caries are visual and tactile (i.e., probing) inspection, and radiographs. However, because of the complicated three-dimensional shape of the occlusal surfaces, incorporating fossae, grooves, and fissures with a great range of individual variations, all these diagnostic methods have the potential to result in errors.

Nevertheless, a minimum set of investigations should consist of the use of visual inspection, tactile inspection and bitewing radiography.

Visual inspection. It is essential that the tooth be dried thoroughly to permit the study of the colour and translucency of the enamel.

In normal fissures and particularly in atypical sticky fissures, most of the early stages of the caries lesions are hidden from the naked eye, although in a clean, dried fissure, it might be possible to observe active noncavitated white-spot enamel lesions on the walls of the entrance of the fissures.

Soon after eruption, most of these lesions are arrested and take up a brown stain from items in the diet. Such arrested fissures should remain caries inactive because functional occlusal wear will not permit any reaccumulation of cariogenic plaque.

Stained fissures occupy an important place within the occlusal lesions. Stained fissures are considered small precavitated lesions in pits and fissures and are about twice as frequent as cavited occlusal lesions. A stained fissure is discoloured, brown or black, white or opaque (enamel normal translucency is lost but there is no evidence of surface cavitation).

The *International Caries Detection and Assessment System (ICDAS II*) provides a standardized method of lesion detection and assessment leading to caries diagnosis. ICDAS II criteria are based on enamel properties of translucency, micro- and macroporosity (Fig. 3). There is an association between ICDAS II scores in the precavitated and first cavitated stages and the lesions histological depth [Ekstrand K. et al., 1997].

For pits and fissures, the evaluation criteria are as follows:

Table 1

Pits and Fissures Evaluation Criteria

Tooth Surface Description	**Evaluation Criteria**	**ICDAS Code**
Sound surfaces	No visible caries when viewed clean and dry. Non-carious white or brown marks on tooth surfaces must be differentiated from early caries lesions	0
Initial stage caries	Characterized by the first visual change in enamel (seen only after prolonged air drying or restricted to the confines of a pit or fissure). OR A distinct visual change in enamel (seen on a wet or dry surface)	1 2

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Tooth Surface Description	Evaluation Criteria	ICDAS Code
Moderate stage caries	Characterized visually by either localized enamel breakdown (without visual sings of dentinal exposure). Enamel breakdown is often viewed best when the tooth is air dried. OR An underlying dark shadow from dentin. Shadowing from dentinal caries is often best seen with the tooth surface wet	3 4
Extensive stage caries	Characterized by distinct cavitation exposing visible dentin. Lesions exhibiting cavitation involving less than half the tooth surface. Lesions involving half of the tooth surface or more	5 6

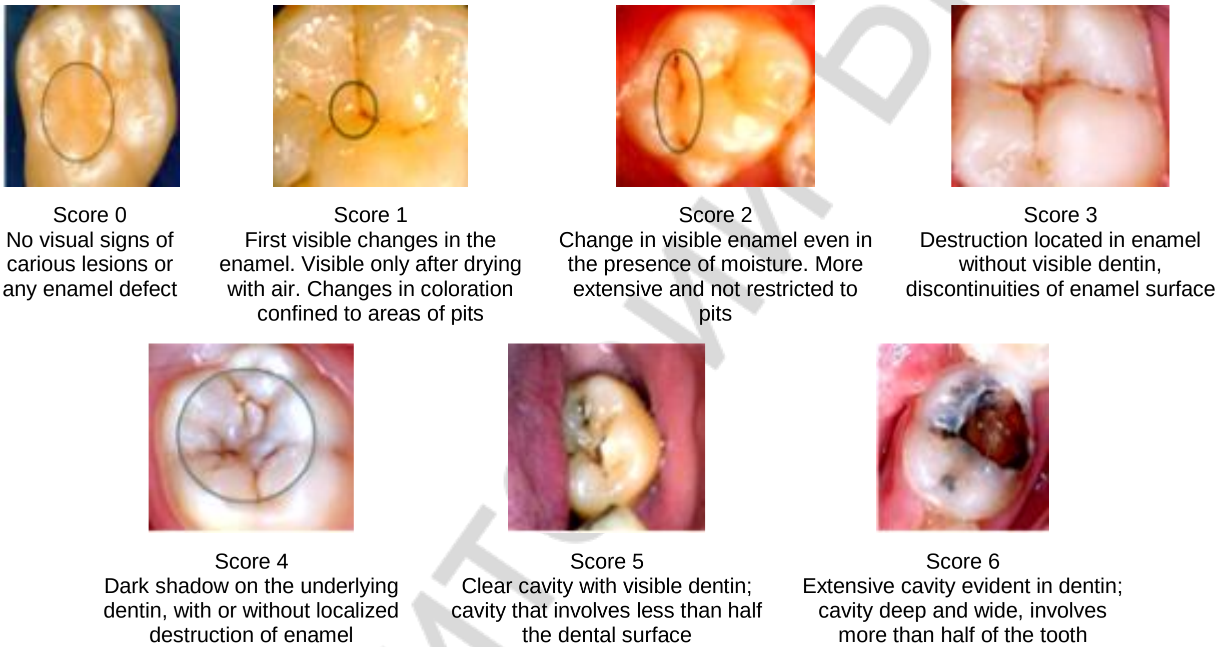

Figure 3. ICDAS II codes and criteria with example photographs

Tactile inspection (probing). The caries lesion usually starts in the enamel on either side of the entrance to the fissures and is visible as a noncavitated white-spot enamel lesion. Gentle probing with a sharp explorer will damage the surface zone of such a lesion and initiate cavitation to the lesion body. A rule of thumb is to use sharp eyes and a blunt probe (or no probe at all) and to arrest the lesion by plaque control and fluoride.

Studies in Europe have shown that the explorer is only correct less than 50 % of the time.

Radiography. Although radiographs, especially intraoral radiographs, have an important role in caries detection, their limitations need to be taken into account, especially when they are used for the detection of incipient and hidden carious lesions.

Radiographs are good for interproximal caries, but ineffective in detecting occlusal caries before it is well into the dentin due to the amount of sound tissue attenuating the beam. Radiographs are more ineffective in detection of occlusal caries before the lesion reaches 1–2 mm in dentine due to the amount of sound tissues after mineral loss of 15–20 %. Even if it is visible on the film, the image usually underestimates the actual size or depth of the lesion.

By the time an occlusal caries lesion is detectable radiographically, it is too large to be treated with non-operative techniques.

Diagnostic coloration (Detection with chemical dyes — Caries Detector). Dyes are a diagnostic aid for detecting caries in questionable areas. Fusayama introduced a technique in 1972 that used a basic fuchsin (fjushin) red stain to aid in differentiating layers of carious dentin (Caries Detector, Kuraray, Osaka, Japan). Some caries detection products contain a red and blue disodium disclosing solution (e.g., Cari-D-Tect, Gresco Products, Stafford, Texas). These products stain infected caries dark blue to bluish-green.

Technique:

1. The area to be tested is rinsed with water and then blotted dry (excess water dilutes a stain).
2. The tooth is treated with a 1 % acid red solution for 10 seconds
3. The tooth is rinsed with water and then excess water is removed. After rinsing with water for 10 seconds, some tooth structure shows Discoloration (stained decay).

Studies show dye stains are about 85 % effective in detecting all caries in a tooth. The method is not informative for immature teeth with incompletely formed enamel mineralization.

New diagnostic tools, based on laser fluorescence or electrical conduction, used in combination with clinical visual inspection, tactile probing of cleaned occlusal surfaces, and bitewing radiographs, can improve the accuracy of diagnosis of occlusal enamel and dentin caries.

Fiber-optic transillumination (FOTI) is a technique that uses light transmission through the tooth and has been available on the market for more than 40 years. Fiber-optic transillumination as a caries detection technique is based on the fact that carious enamel has a lower index of light transmission than sound enamel.

The light is absorbed more when the demineralization process disrupts the crystalline structure of enamel and dentin. Caries or demineralised areas in dentin or enamel show up as darkened areas with this technique. So, if the transmitted light reveals a shadow, this may indicate a carious lesion.

This method of caries detection uses a light source, preferably bright, to illuminate the tooth. This device is only useful for approximal and occlusal lesions; not sufficient for detection of very early caries.

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A recently marketed method based upon the same principles as FOTI is the digitized DIFOTI method. While FOTI was designed for detection of approximal and occlusal caries, digital imaging fiber-optic transillumination DIFOTI is used for detection of both incipient and frank caries in all tooth surfaces.

Digital imaging fiberoptic transillumination (DIFOTI) was developed as a diagnostic tool for early and reliable detection of caries without the need for ionizing radiation. Images of teeth are obtained using visible light via fiberoptic transillumination (FOTI). The method has the potential to enable dentists to detect demineralization on all tooth surfaces. It also can be used to inspect the integrity of the tooth for fractures, decalcification, and wear, and as well as the integrity of amalgams, composites, sealants, orthodontic bands, and so forth. The images can be stored for later retrieval and comparative examination.

Technique. With DIFOTI, a light propagates from the optical fiber through the tooth to a nonilluminated surface (usually the opposite surface). What makes DIFOTI different from FOTI is that the images are acquired by a digital electronic CCD camera. The acquired data are sent to a computer for analysis, which produces digital images that can be viewed in real time (Fig. 4).

Figure 4. The proximal or occlusal mouthpiece is placed over the tooth in question, allowing light to be shined from one surface, through the tooth, and captured on the opposite side using a CCD camera in the DIFOTI handpiece

It is found high sensitivities for caries detection for proximal, occlusal, and root surfaces but lower sensitivities when compared with radiologic images.

There are several limitations of DIFOTI. The method does not measure lesion depth. Furthermore, overdiagnosis can occur owing to lower specificity when compared with conventional radiographs (Fig. 5). Dark areas on the images can be attributed to scatter and the absorption of light as it passes through demineralized enamel and dentin or near the surface; consequently, white spots can be mistaken for cavitations. DIFOTI has the potential not only to detect early lesions but also to monitor the progress of the lesions.

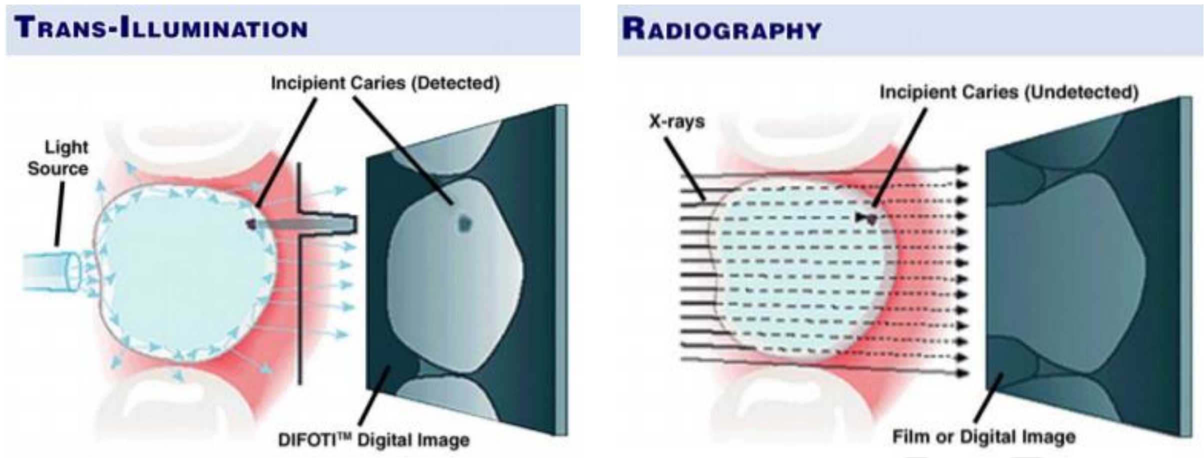

Figure 5. Comparison of radiographic and DIFOTI projection. Typically, tooth decay scatters and absorbs more light than does surrounding healthy tissue. Decay near the imaged surface appears as a darker area against the more translucent brighter background of surrounding healthy anatomy

Light-Induced Fluorescence (LIF). In recent years, different diagnostic methods based on fluorescence have made major advances. Fluorescence is an ability of some materials and tissues to absorb energy at certain wavelengths and emit light at longer wavelengths. Fluorescence is used for diagnostics and several caries detection methods are based on it.

The phenomenon of tooth autofluorescence has long since been suggested to be useful as a tool for the detection of dental caries. An increased porosity due to a subsurface enamel lesion, occupied by water, scatters the light either as it enters the tooth or as the fluorescence is emitted, resulting in a gradual loss of its natural fluorescent properties. Consequently, the demineralized area appears opaque. The strong light scattering in the lesion leads to shorter light path than in sound enamel, and the fluorescence becomes weaker. These changes in fluorescence may be quantified and measured, hence offering a non-invasive diagnostic method.

It is known that bacterial metabolites and chemical substances called porphyrins within caries produce fluorescence that can be enhanced by a laser light.

Quantitative laser fluorescence (QLF) is a method of measuring the induced tooth fluorescence and quantifying tooth demineralization and lesion severity.

The DIAGNOdent is a portable laser diode-based device that is a commercial development of QLF and is designed to aid dental practitioners in the detection of carious lesions (Fig. 6).

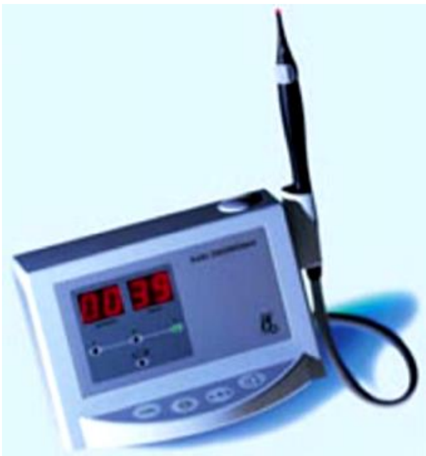

Figure 6. DIAGNOdent machine

DIAGNOdent Classic (KaVo, Germany) is calibrated on sound smooth enamel surface, after drying time of 5 sec. DIAGNOdent emits laser light a 655 nm wavelength that stimulates the fluorescence inside of the lesions and which quantifies a value that ranges between 0 and 99.

When a caries lesion in enamel and dentin is illuminated with red laser light, organic molecules that have penetrated porous regions of the tooth, especially metabolites from oral bacteria, will create an infrared (IR) fluorescence. The enamel is essentially transparent to red light. The IR fluorescence in caries is believed to occur as a result of the luminescence of microorganisms and their metabolic products (porphyrins and related compounds). By using a light-emitting diode (LED) the fluorescence of the dental surfaces is stimulated, as are the porphyrins. The fluorescence received is captured by a receptor; information is processed and analysed and different fluorescence values are generated as a function of the depth of the lesion.

The DIAGNODent does not produce an image of the tooth; instead it displays a numerical value on two LEDdisplays. The emitted light is channeled through the handpiece to a detector and presented to the operator as a digital number. A higher number indicates more fluorescence and by inference a more extensive lesion below the surface (Fig. 7).

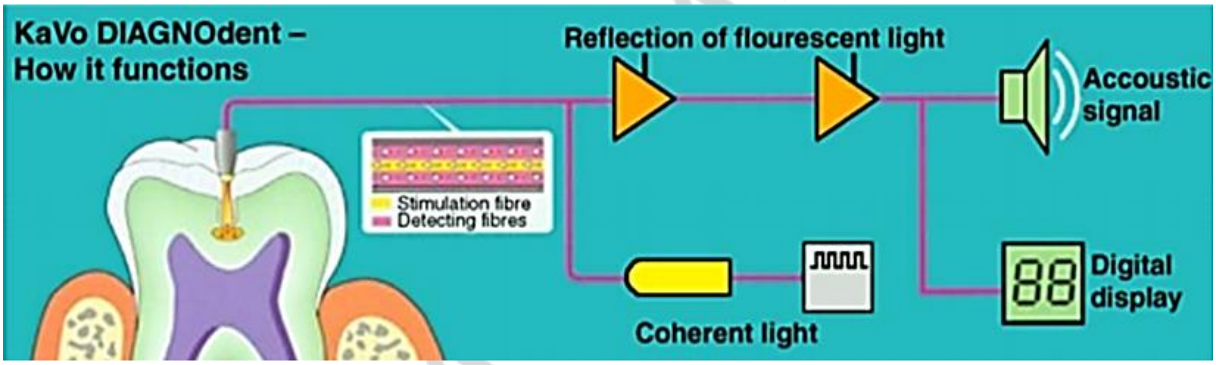

Figure 7. The DIAGNOdent operates at a wavelength of 655 nm. At this specific wavelength, clean healthy tooth structure exhibits little or no fluorescence, resulting in low scale readings on the display. Carious tooth structure exhibits fluorescence proportionate to the degree of caries, resulting in elevated scale readings on the display. An audio signal allows the operator to hear changes in the scale values

Digital numbers on DIAGNOdent:

– Healthy Tooth Structure — 0–10
– Outer Half Enamel Caries — 11–20
– Inner Half Enamel Caries — 21–30
– Dentin Caries — 30+

The sensitivity of the DIAGNOdent device was 0.67 and the specificity 0.79 for enamel caries diagnosis; the measurements showed high reproducibility. In an in vivo study was showed higher sensitivities than bitewing radiographs but lower specificities. Despite these promising results, the QLF technique has several limitations. QLF can only discern enamel demineralization and cannot differentiate decay, hypoplasia, or unusual anatomic features. QLF also does not discriminate between enamel and dentin lesions. Like other methods, QLF cannot differentiate between an active or inactive lesion. In addition, the instrument is sensitive to the presence of stains, deposits, or calculus, which may be falsely registered as a change in enamel or dentin.

Vistaproof Fluorescence Technique (by Dürr Dental, Germany) is ones more the most commonly studied fluorescence-based method. Vistaproof contains a fluorescent intraoral camera used gallium nitride light-emitting diodes (GaN LEDs) that emit blue light at 405 nm light wavelength (Fig. 8).

Figure 8. Vistaproof machine

In this system, the image of the teeth is taken and analyzes putting it into the computer; the resulting mapping of the lesion is produced according to its depth. Vistaproof values are within the range of 0–3. When values are above 2, it indicates dentin caries and changes into orange (Fig. 9).

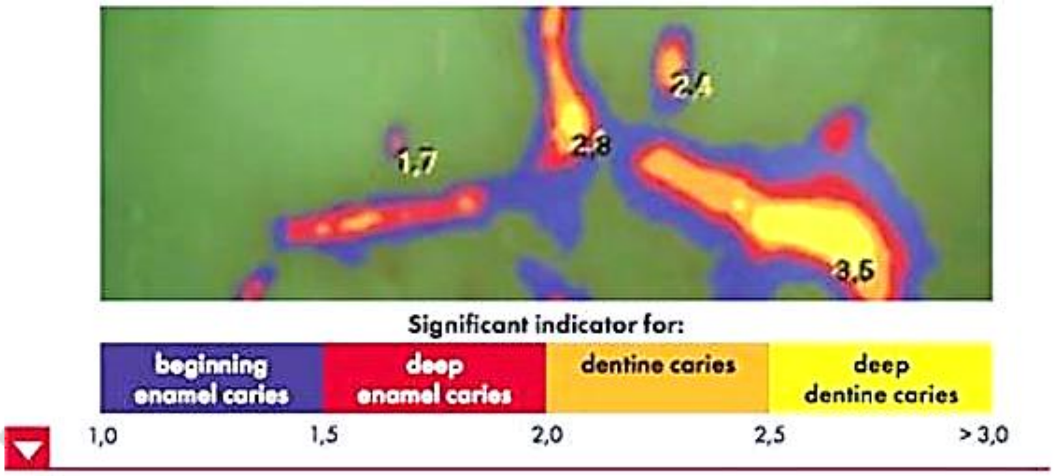

Figure 9. Vistaproof scale

Vistaproof is a method working with fluorescence techniques, but is not sufficient for diagnosis. They are used only to help diagnose. Even though so far, Vistaproof has disadvantages, blue fluorescent gives more accurate results than red fluorescent in the storing the images and also can detect the caries.

SoproLife (ACTEON Group, France). Light-induced fluorescence (LIF) evaluator in daylight and blue light florescence mode is used.

An increased porosity due to a subsurface enamel lesion, occupied by water, scatters the light and teeth emit fluorescence to a less extent than the one of sound tissues.

SoproLife system is invented to combine the advantages of a visual inspection method (high specificity) with a high magnification of intraoral camera and Light-induced fluorescence (LIF) (high reproducibility and discrimination).

In the daylight mode, the system uses four white LEDs; in the fluorescence mode it uses four blue LEDs emitting a wavelength of 450 nm. The tool takes pictures at different distance to a tooth resulting in different magnification: intra-oral from × 30 times to more than 100 times (macro position). The images are recorded with the SOPRO imaging software (Fig. 10).

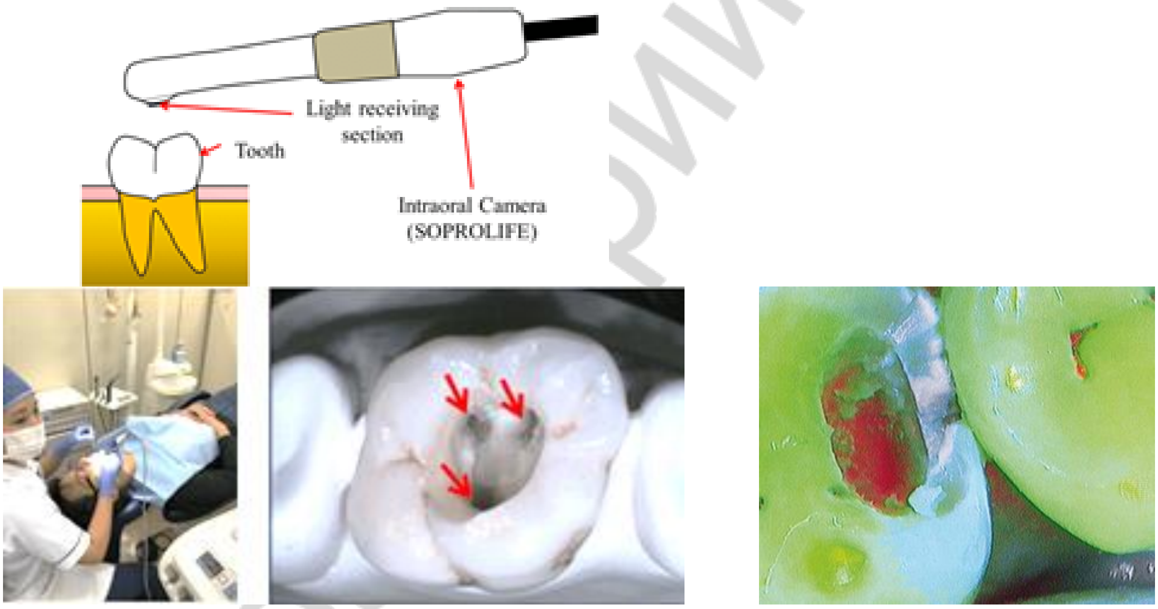

Figure 10. Images of SoproLife diagnostic system

In the Table 2 you can see the comparative characteristics of some methods for diagnosing dental caries.

Table 2

The Applied Diagnostic Criteria

ICDAS II criteria	SoproLife daylight codes for occlusal caries	SoproLife blue fluorescence codes for occlusal caries	DIAGNOdent codes	Histological scale Ekstrand et al., 1997
0 Sound 1 First Visual Change in Enamel (seen only after prolonged air drying or restricted to within the confines of a pit or fissure). 2 Distinct Visual Change in Enamel. 3 Localized enamel breakdown (without clinical visual signs of dentinal involvement). 4 Underlying dark shadow from dentin. 5 Distinct cavity with visible dentin. 6 Extensive distinct cavity with visible dentine	0 Sound, no visible change in the fissure. 1 Center of the fissure showing whitish, slightly yellowish change in enamel, limited to part or all of the pit and fissure system. 2 Whitish change comes up the slopes (walls) toward the cusps; the change is wider than the confines of the fissure, seen in part or all the pit and fissure system, no enamel break down is visible. 3 Fissure enamel is rough and slightly open with beginning slight enamel breakdown; no visual signs of dentinal involvement. 4 Caries process is not confined to the fissure width; presents itself much wider than the fissure. 5 Enamel breakdown with visible open dentin	0 Sound, no visible change in enamel (rarely a graphite-pencil colored thin shine/line can be observed) shiny green fissure. 1 Tiny, thin red shimmer in the pits and fissure system, can come up the slopes, no red dots visible. 2 In addition to tiny, thin red shimmer in pits and fissures possibly coming up the slopes darker red or black spots confined to the fissure. 3 Dark red or black extended areas confined to the fissures; slight beginning roughness. 4 Dark red or black or orange areas wider than fissures; surface roughness occurs, possibly grey/black or rough grey/ black zone visible. 5 Obvious wide openings with visible dentin	0–10 Healthy zone 11–20 Caries in the outer part of the enamel. 21–30 Caries in the inner part of the enamel. +30 Caries in dentin	0 No enamel demineralization or a narrow surface zone of opacity (edge phenomenon). 1 Enamel demineralization limited to the outer 50 % of the enamel layer. 2 Demineralization involving the inner 50 % of the enamel, up to the enamel/dentine junction. 3 Demineralization involving between 50 % of the enamel and outer third of the dentine. 4 Demineralization involving the outer 50 % of the dentine. Demineralization involving the middle third of the dentine. 5 Demineralization involving the inner 50 % of the dentine. Demineralization involving the inner third of the dentine

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The electronic caries measurement (ECM) technique is centered on the theory that sound dental hard tissue, especially the enamel, shows high electrical resistance or impedance. Demineralized enamel becomes porous, and the pores fill with saliva, water, microorganisms, etc. The more demineralized the tissue, the lower the resistance becomes. Tooth demineralization due to caries process causes increased porosity of tooth structure. This lesion porosity contains fluid and less mineral ions. This leads increased electrical conductivity, conversely, leads to decreased electrical resistance or impedance.

A strong relationship between both lesion depth and mineral content in enamel has been shown with ECM readings.

A major advantage of the ECM is the big potential for monitoring lesion progression, arrest, or remineralization.

The electrical conductivity (in mA) the first permanent molars: 6 months after the eruption — 5; 12 months after the eruption — 3; mature (4–6 years) healthy — 0; pigmented tissues without loss — 0.1; with initial caries — 10; with secondary caries — 20; with deep caries — 30.

Site-specific measurements have been evaluated in a number of in vitro studies and in vivo studies. Surface-specific electrical conductance measurements have been investigated under in vitro conditions, which showed moderate sensitivity and specificity.

Optical coherence tomography (OCT) is a nonionizing imaging technique that can produce cross-section images of biologic tissues such as ocular, intravascular, gastrointestinal, epidermal, soft oral tissues, and teeth. OCT can produce two- or three-dimensional images of demineralized regions in dental enamel. When a tooth with a carious lesion is illuminated with infrared light at 1310 nm, OCT technology can produce a quantitative image of the subsurface lesion to the full depth of the enamel. Polarized sensitive OCT (PS-OCT) can be correlated with the degree of demineralization and lesion severity. A potential utility for the system is monitoring in vivo caries lesion changes.

Enameloplasty. The management of the first permanent molar stained surfaces represents a challenge for any paedodontist because these coloured arias often shelter hidden dentinary caries, which “escape” the clinical and radiographic examination. In sticky atypical fissures, none of classic methods can accurately differentiate between non-cavitated and cavitated caries lesions in dentin until advanced, open cavities have developed, which can be verified visually and by probing.

It is of great importance to differentiate between noncavitated and cavitated dentin lesions, because the former can be arrested and treated by odontotomy and preventive restoration with fluoride-releasing resin-modified glass-ionomer sealants (so-called fissure blocking). Thus, for optimized accessibility and correct diagnosis of dentin lesions suspected to be cavitated, the fissures are opened to the bottom, with a pointed diamond bur.

Enameloplasty is a simple, minimal invasive method of diagnosis and treatment, an “excisional biopsy of the enamel”, indicated in cases of stained fissures suspected to hide dentinary caries, in molars and premolars, when the patient has high caries risk.

CARIES MANAGEMENT OF PITS AND FISSURES

Caries can be successfully prevented or at least significantly modified by plaque control, topical use of fluorides, and application of fissure sealants, in particular during eruption. Historically several agents have been tried to protect deep pits and fissures on occlusal surfaces.

Fluorides that protect the smooth surfaces of the teeth are less effective in protecting the occlusal surfaces. Following the use of fluorides, there is a large reduction of incidence in smooth-surface caries but a smaller reduction in occlusal pit-and-fissure caries. This results in an increased proportion in the ratio of occlusal to interproximal lesions, even though the total number may be less.

Studies have shown that with intensified plaque control via a special daily toothbrushing technique combined with fluoride toothpaste, needs-related PMTC, and topical application of 2 % NaF solution during the 12- to 18-month eruption period, it is possible to achieve close 100 % caries prevention and arrest of enamel caries. Other studies have shown that repeated use of fluoride varnish is as efficient as application of resin-based sealants. In addition, use of CHX varnish has proven to provide a significant reduction in occlusal caries and in the amount of the cariogenic Mutans Streptococci in fissure plaque. Such varnishes can be used in the earliest stage of eruption until moisture control can be achieved and thus fissure sealants can be placed.

History of sealing. Several methods have been unsuccessfully used in an attempt either to seal or to make the fissures more resistant to caries. These attempts have included the use of topically applied zinc chloride and potassium ferrocyanide and the use of ammoniacal silver nitrate; they have also included the use of copper amalgam packed into the fissures.

In 1895, Wilson reported the placement of dental cement in pits and fissures to prevent caries.

Method “widening for the sake of prevention” was suggested by Black (1891). According to this method, if caries was detected in some (not all) pits and fissures of the tooth, it was proposed to expand the area of the preparation on the healthy parts, and then fill the entire cavity with amalgam. This method has been used for over 50 years. Disadvantage: a large amount removed tooth tissue for amalgam filling is required.

In 1929, Bodecker suggested that deep fissures could be broadened with a large round bur to make the occlusal areas more self-cleansing, a procedure that is called enameloplasty. Two major disadvantages, however, accompany

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enameloplasty. First, it requires a dentist, which immediately limits its use. Second, in modifying a deep fissure by this method, it is often necessary to remove more sound tooth structure than would be required to insert a small restoration.

In 1923 and again in 1936, Hyatt advocated the early insertion of small restorations in deep pits and fissures before carious lesions had the opportunity to develop. When the tooth was sufficiently erupted, a minimal Class I cavity be prepared and the tooth restored with amalgam before it became carious. In other words, he advocated extension for prevention, according to Black's principles. He termed this procedure prophylactic odontotomy. Hyatt's argument was that it was almost inevitable that the permanent first molar would develop occlusal caries. There was considerable resistance to these proposals from the dental profession, which objected to cutting cavities in caries-free teeth. Hyatt's concept never gained wide acceptance, probably because the procedure involved drilling the child's teeth.

Ones more approach was proposed by Hyatt (1923) and Miller (1950). They attempted to fill the occlusal fissure with a sealant material that, by blocking up the fissure, would prevent bacteria and their substrate from coming into contact with that part of the tooth. Clearly, if successfully retained on the tooth, this material would have a good chance of preventing caries of the underlying enamel. The difficulty was to ensure the retention of the sealing material. Miller (1950) tested the preventive action of black copper cement when used as a fissure sealant. However, the copper cement was not retained on the occlusal surface.

While investigating different methods of improving the marginal seal of acrylic resin restorative materials, Buonocore (1955) decided to test the effect of etching the tooth surface with an acid solution before application of the restorative material. This alteration in technique had a dramatic effect on the adhesion of the resin to the tooth, and acid-etching techniques were soon introduced to the field of fissure sealing.

In the late 1960s and early 1970s, another option became available the use of pit-and-fissure sealants. With this option, a liquid resin is flowed over the occlusal surface of the tooth where it penetrates the deep fissures to fill areas that cannot be cleaned with the toothbrush. The hardened sealant presents a barrier between the tooth and the hostile oral environment. Concurrently, there is a significant reduction of Streptococcus mutans on the treated tooth surface. Pits and fissures serve as reservoirs for Mutans Streptococci, sealing the niche thereby reduces the oral count.

In fact, there had been a long-standing interest in sealing as a method of preventing occlusal caries for more than 100 years.

Pit and Fissure Sealing. Over the last few decades, several advancements have been made in caries prevention. Along with systemic and topical fluoride,

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the increased acceptance and use of pit and fissure sealants have without question had an impact on the prevention of caries.

Sealing is a one of the most popular methods of caries management of pits and fissures nowadays.

Sealing — creating an impermeable mechanical barrier between the microorganisms populating fissures and pits and their oral food sources using adhesive materials placed in fissures.

Rationale for Using Pit and Fissure Sealants:

1. A very high proportion of dental decay occurs in pits and fissures. The change in the pattern of caries in recent years is such that it now principally involves the pits and fissures of molar teeth in children and adolescents. Recent data shows that the relative proportion of pit and fissure lesions has increased to 84 percent of the total new caries experience.

2. Pits and fissures remain at risk of caries for long periods of time, not just within the first few years after eruption. The period of caries susceptibility has extended due to a slowing of the rate of progression of dental caries. Hence, the theory that teeth should be sealed within two years after eruption needs to be reconsidered.

3. Fluoride has limited effect in preventing pit and fissure caries. The effect of systemic or topical fluorides in preventing dental caries is noted principally on the smooth surfaces of teeth; the effect on pit and fissure caries is relatively small. Even with optional fluoride therapy, pit and fissure caries may be delayed, but not prevented, on the same scale as smooth-surface lesions. Approximately 1 mm of enamel is present on smooth surfaces, whereas the base of a fissure may be close to, or even lie within dentine. Thus in the event of fissure caries, the underlying dentine becomes rapidly involved, while on a smooth surface it may take 3–4 years for a lesion to penetrate into dentine. Hence, the inclusion of pit and fissure sealants forms an important part of any caries control program because it is intended for those caries-susceptible areas least benefited by fluoride.

4. Fissure sealants are effective at preventing pit and fissure caries and are best used as part of an overall preventive program.

Sealants protect the occlusal surfaces, inhibiting bacterial growth and providing a smooth surface that increases the probability that the surface will stay clean. It has been documented for decades that sealants are safe and effective.

Purposes of the Sealing:

1. To provide physical barrier to seal off the pit or fissure.

2. To prevent the bacteria and their nutrients from collecting within the pits or fissures to create the acid environment necessary for the initiation of dental caries.

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Nowadays clinicians in their work rely on a guideline panel convened by the American Dental Association (ADA) Council on Scientific Affairs and the American Academy of Pediatric Dentistry in 2016 that content evidence-based clinical recommendations:

– for the use of pit-and-fissure sealants on the occlusal surfaces of primary and permanent molars in children and adolescents;

– and to address clinical questions in relation to the efficacy, retention, and potential side effects of sealants to prevent dental caries;

– their efficacy compared with fluoride varnishes; and a head-to-head comparison of the different types of sealant material used to prevent caries on pits-and-fissures of occlusal surfaces.

Indications for sealing. Sealants should be placed in pits and fissures of children's primary tooth, of children's and adolescents permanent tooth, of adults' permanent teeth, when it is determined that the tooth, or the patient, is at risk of developing caries.

A person may be at moderate or high risk of developing dental caries for a variety of reasons.

Signs of high risk of caries **in a child**: the appearance of ≥ 2 new foci of caries during the last year or the presence of ≥ 2 risk factors:

– high risk of dental caries in parents, sisters and brothers;
– impaired somatic health;
– high frequency of carbohydrate consumption;
– irregular visits to the dentist;
– low level of oral hygiene;
– irregular fluoride use;
– low salivation rate;
– high dmft/DMFT (presence of ECC);
– presence of caries or fillings in fissures.

Signs of high risk of caries **in adult:** the appearance ≥ 3 new foci of caries in last 3 years or the presence ≥ 2 risk factors:

– high frequency of carbohydrate consumption;
– irregular visits to the dentist;
– low level of oral hygiene;
– irregular fluoride use;
– low salivation rate;
– high DMFT.

When assessing the risk of developing caries, the condition of the tooth should be also taken into account. The ***tooth*** is at risk of developing occlusal caries if:

– pronounced (deep, narrow) fissure or pit is present;
– pits and fissures that are anatomically caries susceptible;
– low ability to clean the tooth;

– caries, particularly proximal lesions, exist on other surfaces of the same tooth;

– an intact occlusal surface is present where the contralateral tooth surface is carious or restored.

According to the ADA and AAPD guidelines for secondary prevention, there is evidence that sealants can stop or inhibit the progression of noncavitated carious lesions.

Pit-and-fissure sealants should be placed on early (noncavitated, limited to enamel of pits and fissures) carious lesions in children, adolescents and young adults in adult to reduce the percentage of lesions that progress.

Noncavitated caries lesion refers to pits and fissure in fully erupted teeth that may display discoloration not due to staining or fluorosis. The tooth surface should have no evidence of a shadow indicating dentinal caries, and, if radiographs are available, they should be evaluated to determine that neither the occlusal nor the proximal surfaces have signs of dentinal caries.

Contraindications for sealing. A sealant is contraindicated if:

1. Patient’s behavior does not permit the use of adequate dry field (isolation) techniques throughout the procedure.
2. There is an open occlusal carious lesion.
3. Caries, particularly proximal lesions, exists on other surfaces of the same tooth (radiographs must be current).
4. A large occlusal restoration is already present.
5. If pits and fissures are well coalesced and self-cleansing.
6. Life-expectancy of primary tooth is limited.
7. When patients are allergic to methacrylate.

!!! Remember. Change in caries susceptibility can occur. It is important to consider that the risk of developing dental caries exists continuously and changes across time as risk factors change.

Therefore, clinicians should re-evaluate each patient’s caries risk status periodically.

PIT AND FISSURE SEALANT MATERIALS

The materials used for the sealing, called sealants, respectively. A pit and fissure sealant is a dental material that flows into the pit and fissures and bonds to the enamel surface mainly by mechanical retention. Sealant is a thin plastic coating placed in the pit and fissures of the teeth to act as a physical barrier to decay.

Pit and fissure sealant is a material that is introduced into the occlusal pits and fissures of caries-susceptible teeth, thus forming a micromechanically bonded, protective layer cutting access of caries-producing bacteria from their source of nutrients. Plentiful clinical studies have documented the efficacy of pit and fissure sealants in caries prevention.

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Criteria for the Ideal Sealant:

1. A viscosity allowing penetration into deep and narrow fissures even in maxillary teeth.
2. Adequate working time.
3. Rapid cure.
4. Good and prolonged adhesion/bonding to enamel.
5. Low sorption and solubility.
6. Resistance to wear.
7. Be compatible with the oral tissues (minimum irritation to tissues).
8. Cariostatic action.
9. High retention[2].

There are mainly two groups of materials for the fissure-sealing technique — *Resin-based* and *Glass-ionomer cement*.

Resin-based sealant materials. Resin-based sealants (RBS) are classified into four generations, determined by the method of polymerization. The first group is based on etching of the enamel surfaces with a phosphoric acid (about 35 %) and the use of a cross-linking, thermosetting dimethacrylate monomer (bis-GMA), which is diluted with methyl methacrylate or other co-monomers to increase the flow characteristics to reach the depth of narrow fissures. Etching is necessary to increase the roughness of the enamel surface because the retention of the resin-based sealant is mechanical. The resin forms so-called tags into the microroughness of the etched enamel surface to achieve mechanical retention.

A principal difference is the manner in which polymerization is initiated. The first marketed sealants, called first-generation sealants, were activated with an ultraviolet light source. Second-generation sealants are autopolymerizing (self-curing) and set on mixing with chemical catalyst-accelerator system. The third-generation sealants are phooinitiated with visible light (light-cured). Another recent innovation is the sale of fluoride-containing resin-based sealants and different glass-ionomer materials, which should be regarded as slow-release fluoride agents. Today, the third generation of fissure sealants, with or without fluoride, and chemical or light-cured glass-ionomer sealants are the materials of choice for fissure sealing. Autocured sealant appears to have equivalent documentation of performance compared to visible-light-cured sealant. During the last decade, the light-cured fissure sealants have been most frequently used.

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[2] An important property of pit and fissure sealant is the marginal sealing ability. Defects in marginal sealing will lead to marginal leakage, allowing the passage of bacteria and fluids at the interface of thetooth and the sealant, thus resulting in occurrence of dental caries underneath the sealant. Thus, the success of pit and fissure sealants largely depends upon the long-term retention and tight micromechanical adhesion to enamel surfaces. In pedodontics, maintaining isolation is a tricky task to perform during the process of sealant therapy due to lack of cooperation of the children. Thus, insufficient isolation increases the risk of microleakage, decreased shear bond strength, and subsequent treatment failure. Therefore, use of pit and fissure sealant which requires an easier application and fewer working steps is needed.

Commercially available sealants differ in whether they are free of inert fillers or semifilled and whether they are clear, tinted, or opaque.

Unfilled sealants perform better than filled sealants. Filled sealants have a higher wear resistance, but their ability to penetrate into fissures is low. The filled sealants usually require occlusal control, which lengthen the procedure. The unfilled resin sealants on the other hand have a lower viscosity and provide greater penetration into fissures and better retention. The fissure morphology and the occlusion (e.g. load bearing area) largely dictate the choice between filled and unfilled products.

Clear, tinted, and white opaque resin-based sealants are available. Colored or clear resin sealant is a matter of personal preference; however, it has been shown that the ability to assess retention properly in colored sealants is much less error prone than with clear sealants. Use of an opaque color may interfere with the potential for laser fluorescent diagnosis of caries under a sealant.

The use of an intermediate bonding layer, or the incorporation of the benefits of the advances of the past decade in dentine bonding agents into newly formulated pit and fissure sealants, is a new potential development for the future of pit and fissure sealant materials.

Isolation is a critical for resin sealant, because the technique for use of resin fissure sealant is very sensitive to moisture. Therefore, it may be risky to use it during the eruption of the molars, until the distal fossae and distal margin of the occlusal surface are free of the gingiva. Unfortunately, almost all occlusal caries lesions are initiated during this period.

During the last few years, resin-based fissure sealants supplemented with fluorides have also become available. However, most fluoride is lost during the first few days, and the material, unlike glass-ionomer materials, cannot be recharged with fluoride.

Glass-ionomer cement. Conventional glass-ionomer (GI) material has also been used as pit and fissures sealants, the application technique is less sensitive, than for resins — it is moisture-friendly and easier to place. Glass-ionomer cement is a water-based material that hardens following an acid-base reaction between fluoroaluminosilicate glass powder and an aqueous solution of polyacid. The reaction between GIC and the dental fissures is chemical, so etching of the enamel with phosphoric acid is not required.

Unfortunately, GIC sealants have poor retention. The chemical retention is somewhat weaker than the mechanical retention between resin and an etched enamel surface. However, conditioning of the enamel surfaces with polyacrylic acid can improve the retention of conventional glass-ionomer sealants by about 50 %.

The main advantage of GIC sealant is the continuous fluoride release and fluoride recharging ability. The cement can be recharged with fluorides from topical fluoride agents, such as gels and varnishes. Most of the released fluoride is NaF. Its preventive effect may even last after the visible loss of the sealant as some parts of the material may remain deep in the fissure.

GI sealants can be classified into low viscosity and high viscosity types. High viscosity GIC (“Ketac molar”) called ART sealant is applyed on pits and fissures using the finger-press technique. The later generation GIC (Fuji Triage) has better physical properties and release a higher amount of fluoride.

In fact, GI is considered a temporary sealant and can be useful during tooth eruption, when adequate isolation, to permit the application of resin, is not possible or in patients whose level of anxiety or co-operation similarly prevent placement of resin. But it should be replaced with resin-based sealant when better isolation is possible.

During the last few years, glass-ionomer sealants have been replaced with *resin-modified glass-ionomer sealants*, which achieve favorable physical properties similar to those of resin composites and resin-based sealants while they retain the basic features of the conventional glass-ionomer material, such as fluoride release and chemical adhesion. This type of material was created by incorporating water-soluble resin monomers into an aqueous solution of poly-acrylic acid.

Autopolymerized as well as light-cured resin-modified glass-ionomer sealants are available. However, the recently introduced light-cured resin-modified glass-ionomer sealant (Fuji III LC) is most frequently used. It is popular because of its fast setting reaction and because it is less sensitive to moisture than the etching-resin technique. This is of great importance because the light-cured resin-modified glass-ionomer sealants can be used as early as possible during the eruption of the molars as a combination of fissure sealant and a slow-release fluoride agent.

When resin is incorporated with glass-ionomer, it called *resin-modified glass-ionomer* sealants. Its resin components have improved its physical characteristics, compared to conventional GI. In fact, that it has less sensitivity to water and a longer working-time.

Polyacid-modified resin-based material, which is referred to as *compomer*, is also used as a fissure sealant. It combines the advantageous properties of a visible light polymerized resin-based sealant with the fluoride releasing property of the GI sealant. A polyacid-modified resin-based sealant has a better adhesion property to enamel and dentin and is also less water-soluble, compared to GI sealant material, and less technique-sensitive, compared to resin-based sealants.

TECHNIQUES FOR THE PLACEMENT OF SEALANTS

Depending on the clinical condition in the system of fissures of occlusal surfaces, following variants of sealing technology are recommended:

– preventive sealing — isolation the healthy fissures on a healthy tooth surface using invasive or noninvasive sealing;

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– therapeutic sealing — isolation of fissures with an unclear diagnosis or initial caries using a noninvasive sealing;

– preventive restoration — combination of preparation and restoration of small carious lesion with invasive sealing for surrounding healthy fissures.

PREVENTIVE SEALING

There are two main technological methods of tooth preparation for sealant application.

Noninvasive — without physical invasion in hard dental tissues and with full preservation of tooth tissue.

Invasive — with physical invasion in hard dental tissues and minimal excision the enamel of pits and fissures.

Noninvasive preventive fissure sealing. Advantages of the noninvasive technique are the following:

– conservatism;
– simplicity;
– friendliness to the patient;
– cheapness.

Disadvantages:

– incomplete removal of microbial biofilm;
– preservation of nonprismatic enamel layer;
– fragmentary etching;
– partial filling of fissures
– risk of non-recognition of hidden dental caries.

Noninvasive sealing technique. *Using of resin-based sealants* is following:

Step 1: Prepare the Teeth. Plaque and debris might interfere with the etching process or sealant penetration.

• Clean the pit and fissure surfaces. Utilize a dry toothbrush, prophy cup with pumice or prophy paste, or air abrasion.

• Use an explorer to remove any debris in the pit or fissure.

• The surface is washed with water spray for 20–30 seconds and dried with compressed air.

• Re-evaluate surface for residual or loose debris. A widening of the fissures with rotary instrumentation is yet another type of fissure conditioning that has been recommended before etchant and sealant application. This is known as the invasive pit and fissure technique.

Step 2: Isolate the Teeth. Adequate isolation is the most critical aspect of the sealant application process. Salivary contamination of a tooth surface during or after acid etching will have a deleterious effect on the ultimate bond between enamel and resin.

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• Use cotton rolls, dry angles, and/or rubber dam. Some of the disadvantages of Rubber dam include: discomfort during clamp placement, need for local anesthetic in some instances, difficulty in securely placing a clamp onto a partially erupted tooth, an increase in the cost and need for sterilization of the armamentarium.

• Another alternative to the rubber dam is the Vac-Ejector moisture control system, which consists of a bite block and a rubber tongue shield that is connected to the high-speed evacuation line, providing a clear, dry field for sealant procedures. Clinical studies have found that sealant retention with the Vac-Ejector, either with or without a chairside assistant, is comparable to that with sealants placed under rubber dam or cotton roll isolation.

Step 3: Dry the Surfaces.

• Dry teeth with air for 20–30 seconds.

• Check to make sure there is no moisture coming out of the air syringe tip.

Step 4: Etch the surfaces. There are various etchant materials available, but the most frequently used etchant is 37 % orthophosphoric acid[3]. This is available as both a liquid solution and a gel. One should always apply the etchant onto all the susceptible pits and fissures of the tooth and extend it up the cuspal inclines well beyond (at least 2 millimeters) the anticipated margin of the sealant.

• Apply etchant as directed by manufacturer (usually between 30 and 60 seconds).

• If using a gel or semi-gel apply gel and let stand it for the allotted amount of time.

• If using a liquid continue to apply etchant throughout the etchant time.

Step 5: Rinsing and Drying the teeth.

• Rinse surfaces for 60 seconds.

• Check effectiveness of etchant by drying with air; the surface should become «chalky white».

• If not, repeat etching procedure.

• Place new cotton rolls.

• Dry teeth with air for 20–30 seconds.

[3] The etched or conditioned enamel improves the marginal adaption and bond strength of plastic resin to enamel. Acid conditioning removes old and fully reacted enamel, increases the surface area, and enhances surface porosity. Presently, it is accepted that phosphoric acid is the conditioner of choice, although several other acids — such as pyruvic, citric, and lactic — have also been used to etch enamel prior to the application of resin (Brauer and Termini, 1972; Retief et al., 1976).
Various concentrations of phosphoric, acid, from 30 % to 85 %, have been used to increase surface topography and retention of sealants. It appears that concentrations of 37 % to 50 % phosphoric acid solutions produce the changes in surface topography that are most conducive to bonding (Dennison and Craig, 1978). According to the original recommendations by Buonocore (1955), acid conditioning is usually done for 1 minute, although further studies have shown that improvement may result if etching is extended to 2 minutes for primary teeth. However, a study by Eidelman and coworkers (1974) showed that the retention of sealants is not dramatically affected when the etching time is reduced to 20 seconds.

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Step 6: Application of Sealant Material. During sealant application all the susceptible pits and fissures should be sealed for maximum caries protection. The sealant material can be applied to the tooth in a variety of methods. Many sealant kits have their own dispensers, some are pre-loaded, they directly apply the sealant to the tooth surface:

• Self-curing: Mix equal parts of the two components. Will polymerize in 60–90 seconds.

• Light-curing: Apply with syringe provided by manufacturer. Apply curing light to material. Will be polymerized in 20–30 seconds.

Step 7: Evaluate the Sealant. The sealant should be visually and tactually inspected for complete coverage and the absence of any voids or bubbles. Small voids in the sealant can be repaired simply by adding new material to the void and polymerizing.

Step 8: Occlusal Evaluation. Check occlusion with articulating paper or with green occlusal wax. If necessary, adjustment is performed with filled resins or a pear-shaped finishing bur.

Step 9: Re-evaluation. Recall the patient to evaluated the sealants on the six-month basis.

Light-cured resin-modified glass-ionomer sealants are used according to the following method:

1. Careful PMTC is performed as in the use of resin-based sealants.
2. The occlusal surface is chemically conditioned with 25 % acrylic acid for 30 seconds.
3. Debris in the fissures is removed with a probe.
4. The occlusal surface is washed for 30 seconds and dried.
5. Moisture control measures are carried out, and sealant is applied with a probe or a capsule.
6. The sealant is light cured for 30 seconds.
7. Occlusion is adjusted in a way similar to that described for resin-based sealants.

Invasive preventive sealing. In deep, narrow, sticky fissures, there may be suspected hidden caries in molars that are fully erupted. To achieve accessibility for correct diagnosis, such fissures are opened to the bottom with a pointed diamond bur. In case of a precavitary lesion, of which depth is difficult to specify, or doubtful lesion (stained fissures) in a patient with high caries risk, the treatment decision is an “excisional biopsy of the enamel” named fissurotomy or enameloplasty which is a simple, minimal invasive, method of diagnosis and treatment. This method provides the best diagnosis and the most conservative technique with the maximal preservation of healthy dental structure and the removal of the whole decay.

The suspect arias of the fissural system are explored either with a small round bur at slow rotation or with special fissurotomy burs at high rotation.

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The shape and size of the fissurotomy bur are specifically designed for pit and fissure lesions treatment. Its head length is 2.5 mm, allowing the dentist to control the bur tip to cut just below the dentin-enamel junction and no further. Stained enamel is removed and it is established if the caries enters the dentin or not.

The bur remodels the fissure anatomy, relieving the access, then follows the etching of the preparation and the application of the sealant.

Consequently, Enameloplasty is indicated in the questionable lesions from the pit and fissures surfaces of the primary and permanent molars and premolars when the patient has high risk of caries. enameloplasty allows the dentist to classify the extension of the lesion and then a restorative treatment method is chosen.

The procedure may be accomplished with a minimum of discomfort for the patient (without anaesthesia) being often finished very fast (3–5 minutes), the child acceptance being great.

Advantages of the invasive technique, where the fissures are widened with a small bur before the placement of sealants, are the following:

1. The ability to diagnose the extent of the carious lesion if present and minimize the risk of non-recognition of hidden dental caries.

2. Higher retention rates for sealants are obtained following mechanical preparation of the fissure area.

3. The risk of microleakage is also reduced when the fissure is enlarged.

Disadvantages:

– aggressiveness;

– high demands to materials, technology, personnel;

– expensive;

– relatively high requirements to the patient.

Considering these points, in cases of deep and narrow fissures that are discolored and suspected of being carious, the invasive pit and fissure sealing should be chosen.

Sealant retention. Sealants are both cost-effective and underutilized in prevention of occlusal caries. The long-term efficacy of sealants is well documented. Sealants are lost most frequently fall out from the lingual surfaces of maxillary molars and the buccal surfaces of mandibular molars.

This can be attributed to the shallower pits, which increase the difficulty of complete etching and retention. Most clinicians find that retention rates are less for primary teeth; up to 50 percent are less according to Lein. The theory behind this reduction in retention is the direction of the enamel rods in primary teeth. The ends of enamel rods in permanent teeth form an angle perpendicular to the outer enamel surface, whereas the enamel rods in primary teeth often form an angle that does not allow for optimum retention. Initial retention failure of sealants is historically attributed to technique errors, the most common of which is moisture contamination.

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Other technique errors that can affect retention are inadequate etching, incorporation of air bubbles into the sealant material (which weakens the material), and incomplete removal of debris from the pits and fissures prior to etching.

Sealant retention depends not only on proper application, but also on the eruption status of the tooth. When a tooth is not completely erupted, the retention rate is lower — possibly due to difficulties maintaining a dry tooth surface during application. Without doubt, the retention rate is lowered when an operculum is present over the distal marginal ridge of a molar. One study found a replacement rate of 54 percent on molars when an operculum was present, although no replacement was necessary on molars sealed later in the eruption process.

Undoubtedly, sealants are susceptible to occlusal wear. This is a problem only if the seal at the margins of the sealant is not maintained.

Again, this emphasizes the importance of continued evaluation of the sealant. In the past, fluoride treatment was contraindicated prior to the sealant placement, because it was felt that the fluoride interfered with the bond between the sealant and the tooth surface. Recent research suggests that fluoride used prior to sealant placement may not adversely affect the bonding strength of enamel and sealants.

SEALING OF NON-CAVITATED LESIONS (THERAPEUTIC SEALING)

It should be remembered that due to the difficulty in detecting and diagnosing occlusal caries it is certain that dentists have been inadvertently sealing in caries for decades. According to the ADA and AAPD guidelines there is evidence that sealants can stop or inhibit the progression of noncavitated carious lesions.

It must be acknowledged that the advisability of sealing over dentinal caries has been questioned.

A number of prospective trials suggest that caries progression slows or arrests under sealants. The five-year study from Going et al. monitoring sealed carious lesions, which included bacterial sampling, reported 89 % reversal from caries to non-carious. 9-year study of composite and sealant placed over dentine caries, using clinical and radiographic evaluation, has demonstrated the arrest of the carious process in 63 of the 75 teeth available to follow-up. The number of bacteria in sealed surfaces was less than that found in unsealed surfaces. However, the majority (58 %) of the sealed surfaces still contained cariogenic microorganisms.

The recent systematic review concluded that sealants placed over carious lesions reduced bacteria counts, but that low levels of bacteria might persist without compromising the tooth.

The associated guidelines produced by the American Dental Association concluded: “Sealants are effective in caries prevention and that sealants can prevent the progression of early non-cavitated lesions” or, to paraphrase, “if in doubt seal”. This means there is no place in modern caries management for the enamel biopsy or fissure investigation as is still suggested by some sources.

It is also entirely wrong just to monitor or leave the surface on review, as this inactivity is only likely to lead to caries progression.

Furthermore, the balance of evidence is clearly in favour of sealing non-cavitated occlusal carious lesions, even those with radioluncencies extending up to a third into dentine. This decision as with all treatment decisions should be based on a full risk assessment.

As soon as a cavity is identified, conventional restorative methods must be implemented. In case of an intact enamel layer — a so-called non-cavitated lesion — the application of a sealing material should be considered. This method arrests the progression of this hidden caries and therefore conserves the tooth structure by means of delaying and minimizing operative procedures. A systematic review on this topic reported that sealing with resin-based materials arrested the progression of carious lesions.

Therefore, the lesions seen in Figures 11–14 should both be managed by sealing.

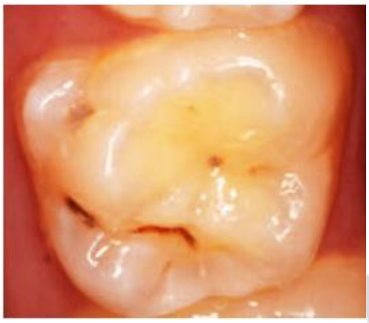

Figure 11. Possibly carious occlusal fissure upper left first permanent molar (tooth 26)

Figure 12. Bitewing radiograph of upper left 6 (26) seen in Fig. 1. Although there is mesial enamel caries the tooth appears sound occlusally

Figure 13. Possibly carious occlusal fissure upper right first permanent molar (tooth 26)

Figure 14. Bitewing radiograph of upper right 6 (16) see in Figure 3, suggesting the presence of dentine caries in the occlusal palatal fissure

MINIMALLY INVASIVE PREVENTIVE RESTORATION

If a cavitated lesion in the dentin is discovered when the fissure is opened, a minimally invasive preparation is performed to minimize loss of tooth material.

Minimal invasive therapy is a new concept in paediatric dentistry, which combines early diagnosis with the ultraconservative preparations.

When diagnosis is well defined, treatment decisions are easy to make. I.e. if a tooth is newly erupted and the fissure system is unstained but considered at risk for caries, fissure sealing is recommended.

When there is occlusal cavitation that is synonymous with an extensive lesion, a restorative approach is recommended.

One approach to dealing with the problem of early fissure caries is to use a procedure called *Minimally invasive preventive restoration*.

In this technique is uesed a minimally invasive resin composite or resin-modified glass-ionomer cement restoration. The technique involves making a very small, local cavity preparation in the immediate area of the fissure system at which the presence of caries is suspected. No attempt is made to extend the cavity beyond the immediate area affected by caries. The defect in the occlusal surface is restored with a resin composite, or a type II resin-modified glass-ionomer restorative material, depending on the size of the defect. Following this, the etched occlusal surface of the tooth may be sealed over the top of any minirestoration with resin composite or resin-modified glass-ionomer material.

Depend on used material for restoration, 2 techniques are possible.

• Preventive resin restorations (PRR) is a 20-year-old concept first reported by Simonsen and Stallard (1978). The procedure involves removal of those areas of teeth which were affected by caries with following filling them using resin restorative material and finally covering all restorative material and any remaining fissured anatomy with sealant. This method is indicated where caries within a fissure has just reached the dentine.

• PGIR (preventive glass ionomer restoration) preposes using og glass ionomer cement for restoration and the following covering of fissures system with a sealant.

The advantage of these approachs is that the absolute minimum of tooth substance is removed. By avoiding the old philosophy “extension for prevention” the tooth preparation and replacing it with the idea of discrete removal of caries, there is a major reduction in intracoronal preparation and tooth structure loss. The procedure avoids the unfortunate consequences of an error in diagnosis.

If a healthy tooth is investigated, little harm is done, for it quickly becomes evident that no caries is present and the resulting cavity is very small. If the caries is more extensive than was originally supposed, this will become apparent during the procedure, and appropriate action can be taken.

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An attractive alternative to flowable resin composite or compomers is type II light-cured resin-modified glass-ionomer cement.

The advantages Minimally invasive preventive restorations are:

1. There is minimal removal of the tooth structure, hence, greater the tooth strength.
2. There is no marginal leakage, with a reduced risk of recurrent caries.
3. Local anesthetic is not normally required.
4. The restoration can be completed in one visit and polishing is not required.
5. Caries in adjacent pits and fissures is prevented without fissure removal.
6. Pleasing aesthetics are obtained.
7. The restorations are cost-effective and can be easily repaired.

After fissurotomy, there are many clinical situations:

1) the decay ends in the enamel; fissure sealant is recommended to all of the adjacent fissures (invasive sealing);

2) the decay progresses into the dentine but has minimal lateral spreading; preventive resin restoration (PRR) is recommended;

a) superficial dentinal caries; it is recommended: liner/varnish, flowable composite resin restoration and fissure sealant (PRR type 1);

b) medium dentinal caries; it is recommended: glass-ionomer cement (GIC) base, posterior resin restoration/compomer restoration and fissure sealant (PRR type 2);

c) deep dentinal caries; it is recommended: indirect capping with calcium hydroxide, GIC base, resin restoration and fissure sealant (PRR type 3). The tooth is periodically followed up (at 4–6 months) for checking up the integrity of the sealant;

d) caries with significant lateral spread into dentine (it is recommended: classic amalgam or posterior resin restorations).

NEEDS-RELATED PROGRAMS FOR PREVENTION OF OCCLUSAL CARIES

From a cost-effectiveness point of view, use of fissure sealants should be based on detailed risk prediction as an integrated measure in needs-related caries-preventive programs. However, there are some general principles for the use of sealants:

1. Light-cured resin-modified glass-ionomer sealants should be used as early as possible during the eruption of the molars as a fissure protector, that is, at 5.5 to 6.5 years (first molars) and 11.5 to 12.5 years (second molars), and, on average, 6 months earlier in girls than in boys.
2. Fissure sealants should be used more frequency in populations with high caries prevalence than in those with low caries prevalence.

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3. Fissure sealants should be used more frequency in caries-risk individuals and molars with sticky atypical fissures.

Instructions to the Patient or Parent. It is necessary to receive consent from the parent or guardian of a minor or a mentally impaired patient prior to placing a sealant. The patient and/or parent must understand that sealants can only help prevent caries on the tooth surfaces where the sealants are applied; and that plaque control, fluoride therapy, and sugar discipline are still necessary to prevent decay on the rest of the tooth surfaces. Discuss the life-expectancy (the retention rate, which varies from patient to patient) of sealants with the patient/guardian. Use a mouth mirror whenever possible to show the patient and/or parent which tooth has been sealed. Explain that it may feel “high” immediately after placement, but that it should feel normal in two to three days due to normal chewing action. If it does not, the patient should return to the dental office to have the excess height reduced.

The patient or parent should be advised to check the sealant during routine oral hygiene procedures and to contact the dental office if there is any sign of sealant loss or breakage.

Inform the patient or parent of the need for six-month recall appointments to monitor sealant retention. At the recall appointment, the sealed tooth should be categorized and treated according to one of the three following categories (Table 4).

Table 4

Criteria for pits and fissures management at the recall appointment

Recall status of tooth	Treatment
1. All pits and fissures covered	No treatment required
2. Sealant missing from some or all the pits and fissures, exposed surface is sound	Reseal the exposed pits and fissures (i.e. sealant replaced)
3. Sealant missing from some of all of the pits and fissures, caries is present	Restore carious pits and fissures (i.e. restorative procedures)

Caries-preventive effects. Fissure sealants placed with the etching-resin technique are effective as long as they remain firmly adherent to the tooth. Early split-mouth studies of this technique resulted in about a 50 % caries reduction in populations with high incidence of caries. However, in populations with a low incidence of caries, less caries prevention may be expected. Thus, general use of fissure sealants in populations with a low prevalence of caries is not cost effective. In such populations, the use of fissure sealants should be restricted to caries-risk patients and molars with atypical sticky fissures as an integrated measure in needs-related caries-preventive programs.

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In studies comparing the effect of glass-ionomer or light-cured resin-modified glass-ionomer sealants with resin-based sealants, the former have resulted in at least the same caries-preventive effect as the latter, in spite of their shorter period of retention. This may be attributed to the release of fluoride from the glass-ionomer sealants.

From a caries-preventive point of view, the optimal effect should be achieved by the use of sealants as early as possible during the eruption because almost 100 % of occlusal caries is initiated during the extremely long eruption period (12 to 18 months) of the molars. If the occlusal surfaces of the molars are maintained caries free until they have reached full occlusal and functional wear, the risk for initiation of caries is over. Therefore, light-cured resin-modified glass-ionomer sealants should be used as early as possible during the eruption of the molars as the first choice of sealants. Because of their combined sealant and slow-release fluoride effect and lower sensitivity to moisture, light-cured resin-modified glass-ionomer materials should be regarded as a very efficient fissure protector rather than a long-lasting fissure sealant.

Cost-Effectiveness. Sealant effectiveness and cost-effectiveness are dependent upon disease levels and the selection of patients and tooth surfaces to be sealed. Thus, another critical way in which sealant usefulness can be increased is by developing and applying evidence-based caries risk assessments to individual patients.

To achieve maximum benefit sealants should:

- Be used for targeted prevention in high risk children and young adults.
- Be applied to teeth such as mandibular molars that are likely to develop caries.
- Be used in connection with other preventive measures.
- Employ contemporary resin materials (second or third generation resins), or glass ionomers with appropriate viscosity and surface wetting properties.
- Be placed by dental auxiliaries (dental therapists or dental hygienists) to reduce their overall cost.
- Be monitored overtime and re-applied as needed.

The British Society of Pediatric Dentistry (2000) has stated that “Sealants are highly effective in preventing dental caries in pits and fissures of teeth when applied by trained operators in clinical trials and community health programs. When used appropriately, sealants result in improvements in oral health but their use on all occlusal tooth surfaces for preventive reasons will result in wastage of scarce resources”. Sealing of pits and fissures in all patients may be considered to be ideal treatment and is justified for all patients classified as “high risk”. However, financial and other constraints demand that guidelines for patient and tooth selection should be established.

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