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Use of new minimum intervention dentistry technologies in caries management

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ABSTRACT

Preservation of natural tooth structure requires early detection of the carious lesion and is associated with comprehensive patient dental care. Processes aiming to detect carious lesions in the initial stage with optimum efficiency employ a variety of technologies such as magnifying loupes, transillumination, light and laser fluorescence (QLF® and DIAGNOdent®) and autofluorescence (Soprolife® and VistaCam®), electric current/impedance (CarieScan®), tomographic imaging and image processing. Most fluorescent caries detection tools can discriminate between healthy and carious dental tissue, demonstrating different levels of sensitivity and specificity. Based on the fluorescence principle, an LED camera (Soprolife®) was developed (Sopro-Acteon, La Ciotat, France) which combined magnification, fluorescence, picture acquisition and an innovative therapeutic concept called light-induced fluorescence evaluator for diagnosis and treatment (LIFEDT). This article is rounded off by a Soprolife® illustration about minimally or even non-invasive dental techniques, distinguishing those that preserve or reinforce the enamel and enamel-dentine structures without any preparation (MIT1– minimally invasive therapy 1) from those that require minimum preparation of the dental tissues (MIT2 – minimally invasive therapy 2) using several clinical cases as examples. MIT1 encompasses all the dental techniques aimed at disinfection, remineralizing, reversing and sealing the caries process and MIT2 involves a series of specific tools, including microburs, air abrasion devices, sonic and ultrasonic inserts and photo-activated disinfection to achieve minimal preparation of the tooth. With respect to minimally invasive treatment and prevention, the use of lasers is discussed. Furthermore, while most practices operate under a surgical model, Caries Management by Risk Assessment (CaMBRA) encourages a medical model of disease prevention and management to control the manifestation of the disease, or keep the oral environment in a state of balance between pathological and preventive factors. Early detection and diagnosis and prediction of lesion activity are of great interest and may change traditional operative procedures substantially. Fluorescence tools with high levels of magnification and observational capacity should guide clinicians towards a more preventive and minimally invasive treatment strategy.

Keywords: Caries, fluorescence, minimally invasive dentistry, LIFEDT concept.

Abbreviations and acronyms: CaMBRA = Caries Management by Risk Assessment; CRE = caries removal effectiveness; ECC = early childhood caries; ICDAS = International Caries Detection and Assessment System; LIFEDT = light-induced fluorescence evaluator for diagnosis and treatment; MID = minimum intervention dentistry; MIP = minimal invasive potential; MIT1 = minimally invasive therapy 1; MIT2 = minimally invasive therapy 2; NIR = near infrared radiation; OCT = optical coherence tomography; PS-OCT = polarized sensitive optical coherence tomography.

INTRODUCTION

Appropriate treatment of dental caries demands detection of carious lesions at an early stage. Previous caries experience is the best predictor of future caries. Additionally, a caries risk assessment can help to determine the caries risk status of an individual. The development of technology to detect and quantify early carious lesions as well as caries activity may help to identify patients who require intensive preventive interventions best.[1–3] All methods for detection and quantification of dental caries require certain conditions: they have to meet all safety regulations; detect early shallow lesions; differentiate between shallow and deep lesions; give a low proportion of false positive readings; present data in a quantitative form so that caries activity can be monitored; be precise so that measurements can be repeated by several operators; be cost-effective and user-friendly.[4] Many new caries classifications have been published, and the main issues are to be certain that the diagnosis device and the classification used fits within the framework of the daily dental practice routine.[5] The introduction of a caries management system in correlation with the caries risk assessment, Caries Management by Risk Assessment (CaMBRA) and evidence based management options for non-cavitated and cavitated lesions might depend on these new diagnostic technologies. The goal of this review is to give an overview of these new minimum intervention dentistry (MID) technologies assigned to diagnose and treat caries in a precavitated or cavitated stage using a medical approach.

New detection methods can be based on light transmission, light fluorescence and other systems such as ultrasound and near infrared illumination.

Light transmission

Fibre optic transillumination (FOTI®, DIFOTI, Electro-Optical Sciences, Irvington, NY, USA), and the more recent digitized DIFOTI® technique, use light transmission through the tooth.[4,6–8] The images can be stored and re-examined later. Fibre optic transillumination with a camera from KaVo®, the DIAGNOcam® (KaVo Dental, Lake Zurich, IL, USA) is a new system developed recently, also based on simple transillumination (excitation wavelength of 780 nm) (Fig. 1). So far only limited research has been published. The DIAGNOcam® is placed directly on the tooth, the transilluminating light positioned either side of the tooth and the picture captured; the software allows storage of the picture.

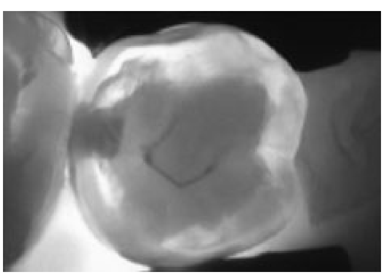

Fig. 1 Tooth picture taken with the DIAGNOcam camera.

Light fluorescence

The imaging techniques based on the fluorescent response of organic components of teeth have been developed for use in caries detection. Commercially available devices include fluorescence systems, a combination of camera and fluorescence systems, optical coherence tomography, and electrical impedance and conductivity.

Fluorescence systems

The DIAGNOdent® (DIAGNOdent 2095, DIAGNOdent 2190, KaVo Dental, Lake Zurich, IL, USA), which uses a laser at a wavelength of 655 nm, creating fluorescence in components such as porphyrins, and the intensity of the emitted fluorescent light is measured.[13–15] DIAGNOdent® values guide clinical decision making (Table 1). After calibration of the tool on a ceramic disc or sound adjacent enamel, the detection handpiece is placed on the tooth surfaces and the device provides a value which can be recorded.

Fluorescence Aided for Caries Excavation (FACE, SIROInspect®, Sirona Dental Systems GmbH, Germany) (Fig. 2 and 3) has an excitation wavelength of around 405 nm. The practitioner needs to use specific glasses to see the fluorescence in dentine.[16,17] Limited information is presently available. No images can be recorded with either system. The Midwest Caries ID unit (Dentsply, York, PA, USA) uses LED illumination and feedback relating to caries status is provided via audible ‘beeps’. Very little information or research is available.

Combination of camera and fluorescence systems

The QLF® (QLF, Inspektor Research Systems BV, Amsterdam, Netherlands), with emission in the wavelength region of 290–450 nm, uses a xenon arc lamp and looks at the change in transmission from the green fluorescence occurring in the dentine body due

Table 1. Laser fluorescence scores and clinical recommendations

DIAGNOpen score	Interval 1	Interval 2	Interval 3
Occlusal and pits	0–12	13–24	>25
Histological interpretation	Healthy tissue	Demineralized enamel	Dentine involved
Recommended therapy	Normal prophylactic care	Intensive prophylactic care	Minimally invasive operative care
Proximal area	0–7	8–15	>16
Recommended therapy	Normal prophylactic care	Intensive prophylactic care	Minimally invasive operative care

Fig. 2 SIROInspect® (from Sirona website).

Fig. 3 Red fluorescence emission of dentine after excitation with SIRO-Inspect (from Sirona website. Buchalla W).

to microporosities in enamel as a result of the caries acid attack.[18–21] In brief, the QLF system's ability is to accurately determine mineral content of enamel.

The Canary® (Quantum Dental Technologies Inc. Ontario, Canada) is a laser-based system that uses a combination of heat and light (Frequency Domain Photothermal Radiometry and Modulated Luminescence; FD-PTR and LUM) claiming to examine the crystal structure of teeth and map areas of tooth decay directly.[22–25] The Canary uses a low power, pulsating laser light to scan teeth for the presence of dental caries. The tooth absorbs the laser light and two phenomena are observed and measured: the laser light is absorbed and then consequently a release of heat occurs. This heat will not harm the tooth. By varying the pulse of the laser beam, a depth profile of the tooth can be created to permit detection of decay as deep as 5 mm from the tooth surface and as small as 50 microns in size. Simultaneous measurement of the reflected heat and light provides information on the presence and extent of tooth decay below the tooth surface before being detected by dental radiographs. The device is supposed to provide early detection of small cavities, and thus is more advantageous in comparison to traditional approaches for detection and monitoring early stage tooth decay. This might reduce the cost barriers to dental services by treating emerging 'cavities' before invasive and more expensive treatments are required. The handpiece is applied on the tooth, pictures and 'Canary' values are given by the system. Protective glasses are recommended.

The Soprolife® camera (Acteon, La Ciotat, France)[3,4,26–31] is an intraoral camera that utilizes two types of LEDs that illuminate tooth surfaces in the visible domain, either in the white light region or in a narrow band (wavelength 450 nm with a bandwidth of 20 nm). This provides an anatomical image superimposed on an autofluorescence image. The device can detect and locate differences in density, structure and/or chemical composition of biological tissue by continuously illuminating with one frequency band while it generates a fluorescence phenomenon in a second frequency band. The camera is equipped with an image sensor (0.25-inch CCD sensor) consisting of a mosaic of pixels covered with filters of complementary colours. The data collected, relating to the energy received by each pixel, allows retrieval of an image of the tooth. The camera operates in three modes: for daylight mode four white light LEDs are engaged; for the diagnostic and treatment modes the light is provided by four blue LEDs (450 nm). A new camera, the Soprocare®, also provides three clinical modes: daylight, caries and periodontal mode. The caries mode focuses on enamel and dentine caries, and the periodontal mode on periodontal inflammation. Table 2 gives an overview of the fluorescence signals for coronal caries and Table 3 focuses on the observed dentine signal.

The LIFEDT concept[26,27] (light induced fluorescence evaluator for diagnosis and treatment) is linked to the fluorescence camera. The principles are: (1) the occlusal surfaces of the tooth of interest are cleaned; (2) the tooth can be observed in daylight and fluorescence mode with a high level of magnification; (3) any modification of the reflected light from dentine or enamel in comparison to a healthy area can be noted; (4) clinical decisions are not linked to numerical values but the system improves visual inspection and helps in decision making.

Soproimaging® software makes it possible to record and compare the pictures. The camera is positioned on the tooth, with magnification and mode (daylight or fluorescence) selected. Pictures are recorded with the specific Soproimaging® software.

The VistaCam® camera (Classic, CL and IX) is an intraoral fluorescence camera (Dürr Dental, Bietigheim-Bissingen, Germany) that illuminates teeth with a violet light (405 nm) and captures the reflected light as a digital image (Fig. 4). The reflected light is filtered for light below 495 nm and contains the green-yellow fluorescence of normal teeth with a peak at 510 nm, as well as the red fluorescence of bacterial metabolites with a peak at 680 nm. The software (DBSWIN version 5.3) quantifies the green and red components of the reflected light on a scale from 0 to 3 as a ratio of red to green (Table 3), showing the areas with a higher than healthy tooth ratio. A new version, the VistaCam CL-IX® with removable head cameras, wireless and a light cure function, has just been launched.[32,33] The camera is placed on the tooth, pictures are recorded with specific software, which then reveals the caries scores.

Table 2. Soprolife® in daylight and blue fluorescence codes for coronal caries according to Rechmann *et al.*[4] Treatment decision proposition

Code. Visual inspection	Description in daylight after cleaning	Description in fluorescence after cleaning	DIAGNOdent versus Spectra Caries (VistaCam®) detection. Average value (±SD)	Treatment decision proposition
0	Sound, no visible change in the fissure	Sound, no visible change in enamel (rarely a graphite-pencil-coloured thin shine/line can be observed) shiny green fissure	5.7 (±4.3) 0.7 (±0.68)	MIT1 + CAMBRA recommendations
1	Centre of the fissure showing whitish, slightly yellowish change in enamel, limited to part or all of the base of the pit and fissure system	Tiny, thin red shimmer in the pits and fissure system, can come up the slopes, no red dots visible	13.3 (±11.8) 1.26 (±0.61)	MIT1 + CAMBRA recommendations
2	Whitish change comes up the slopes (walls) to ward the cusps; the change is wider than the confines of the fissure, seen in part or all of the pit and fissure system, no enamel breakdown is visible	In addition to tiny, thin red shimmer in pits and fissures, possibly coming up the slopes darker red spots confined to the fissure are visible	22 (±17.5) 1.6 (±0.51)	MIT1 + CAMBRA recommendations
3	Fissure enamel is rough and slightly open with beginning slight enamel breakdown; changes are confined to the fissure and do not necessarily come up the slopes, no visual signs of dentinal involvement	Dark red extended areas confined to the fissures; slight incipient roughness	40.6 (±24.6)/ 1.95(±0.57)	MIT1 + CAMBRA recommendations
4 Reasonable cut-off point	Caries process is not confined to the fissure width; appears much wider than the fissure; changed area has a 'mother-of-pearl' glossy appearance	Dark red or orange areas wider than fissures; surface roughness occurs, possibly grey or rough grey zone visible		MIT2 Operative steps
5	Enamel breakdown with visible open dentine	Obvious wide openings with visible dentine		MIT2 Operative steps

Table 3. Clinical dentine colour guide used with the LIFEDT concept and the Soprolife® device[3,26,27]

Camera. Visual inspection	Healthy dentine	Infected dentine	Affected dentine. Active process (soft-yellow-tissue)	Affected dentine. Arrested process (brown-tissue, quite hard)
Soprolife®	Acid green	Dark grey	Bright red	Dark red
Soprocare®	Grey	Dark grey	Bright red	Dark red

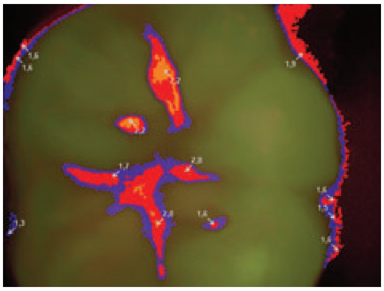

Fig. 4 VistaCam® picture of occlusal decay with their respective caries ratios.

All these devices can be used specifically for diagnostics or treatment, but at this time only Soprolife® can be used for both.

Optical coherence tomography

Optical coherence tomography (OCT, Dental Imaging System, Lantis Laser, Denville, NJ, USA) is a non-ionizing imaging technique that can produce cross-section images of biological tissues using an infrared light at 1310 nm. Only *in vitro* studies are available, and often the images are limited to the depth of enamel. The polarized sensitive OCT (PS-OCT) can be correlated with the degree of demineralization and lesion severity. Monitoring *in vivo* carious lesion changes could be helpful with this device.[34–36] A combination of near infrared radiation (NIR) imaging with PS-OCT was also described to acquire depth-resolved images. Combining this technology with a short-pulsed CO_2 laser ablation system would allow for the selective removal of dental caries.

Electric impedance and conductivity

The Electronic Caries Monitor (ECM®, Lode Diagnostics, Groningen, the Netherlands) is based on tissue electroconductivity and CarieScan® on electric impedance. The CarieScan® (Dundee, Scotland) technique originates from the theory that sound dental hard tissue exhibits high electrical resistance or impedance. The more demineralized the tissue, the lower the resistance becomes. *In vitro* and *in vivo* studies were performed, showing moderate sensitivity and specificity.[9–12] Measures are linked with a scale number giving information about the supposed severity of the decay (Table 5). The metallic probe of the CarieScan® is

Table 4. VistaCam scores and colour scales versus the histological scale

0–1	1–1.5	1.5–2	2–2.5	2.5 >3
Healthy enamel	Initial enamel demineralization	Deep enamel decay	Dentine caries	Deep dentine caries

Table 5. CarieScan® score versus ICDAS II classification and histological classification

CarieScan site status Reference standard *validated by Micro-CT plus visual examination*	CarieScan code	ICDAS code *validated by clinical visual examination*	ICDAS site status *validated by histological examination*
Sound	0	0	Sound
Sound-outer 1/3 enamel caries interface	1–20	0	Sound
Enamel caries	21–30	1	Enamel caries
outer 1/3 enamel			*outer 1/2 enamel*
middle 1/3 enamel	31–50	2	*inner 1/2 enamel*
inner 1/3 enamel	51–90		
Enamel and enamel – dentine junction / outer half dentine caries	91–99	2	*inner 1/2 enamel* *outer 1/3 dentine*
Established dentine caries	100	3, 4, 5, 6	Dentine caries
inner 1/2 dentine			*middle 1/3 dentine* *inner 1/3 dentine*

directly placed on the tooth and the caries values are given by the system. A lip hook is needed.

Other systems

Other systems include ultrasound, near-infrared illumination, Raman spectroscopy and terahertz imaging. Further research is still required before these systems can clinically be used. Sensitivity, specificity and advantages of the main different devices are summarized in Tables 6 and 7.

Illustrations with clinical cases

Clinical recommendation for the diagnosis step

For caries diagnostics the use of a combination of diagnostic aids is still recommended.[37] Whatever numerical values given by the device,[35,36] visual inspection remains an essential component in making the final decision: to drill or not to drill. Indeed it is more the complexity of the shape, depth and the width of the grooves which governs clinical decision, meaning that before the diagnostic step the pits need to be perfectly clean. Regarding the treatment, after the diagnosis has been established, many new products are now available with the aim of remineralization and reversing the caries process. Their systematic use should be promoted.[38–40] The general philosophy of the patient-centred approach is of importance. Indeed, all the techniques described below should be applied within a modern medical approach of determining and managing the patient's caries risk by applying the CaMBRA system.[41,42] The threshold of invasive intervention is given at a lesion with first visible enamel breakdown (ICDAS score 3). The choice between advising preventive care and the preventive with operative care, respectively will be based on this decision.[43,44] Consequently, preventive and minimal invasive therapies can be divided into two groups: the first (minimally invasive treatment 1 or MIT1) for treating enamel and enamel-dentine lesions without any preparation ('non-invasive'), provided that there is no surface cavitation. The second group (minimally invasive treatment 2 or MIT2) is for treating early enamel-dentine lesions with surface cavitation. From ICDAS score 3 onwards, a more conventional therapeutic approach is advisable (Table 2).[3,4,26,27]

Table 6. Sensitivity and specificity of the main different devices[4,37]

Devices	Sensitivity	Specificity
Electronic caries monitor®	0.65	0.73
Visual inspection	0.6	0.73
Fibre optic transillumination®	0.21	0.88
Bitewing	0.19	0.80
QLF®	0.5–0.68	0.7–0.9
Spectra® or VistaCam®	0.92	0.37
SiroInspect	0.94	0.83
DIAGNOdent®	0.87	0.5
SoproLife®	0.93	0.63

CaMBRA: a paradigm shift in dentistry

Dental caries is the most prevalent infectious disease in children in the USA.[45] Caries is five times more common than asthma and seven times more likely than hay fever in children.[46] More than 40% of children have tooth decay by the time they reach kindergarten.[47] Recent research has shown that early preventive dental visits (by age 1) are effective at preventing early childhood caries (ECC, or severe tooth decay in children under 5) and can reduce total dental costs.[48]

Caries results from an overgrowth of specific organisms (*Streptococcus mutans*, lactobacillus species) that are part of normally occurring human dental flora. Infant colonization with *S. mutans* commonly occurs through vertical transmission from mother to child. Children of mothers with high caries rates are at higher risk of ECC.[49] Other factors which contribute to the overgrowth of cariogenic organisms include frequent ingestion of fermentable carbohydrates and reduced salivary function.

The caries process is most effectively managed by assessing each patient's individual risk factors (the balance/imbalance of protective factors and pathological factors) and by prescribing appropriate non-surgical interventions. The conventional restorative approach alone will not eliminate the disease of caries.[50]

Table 7. Main advantages of the respective devices

Main devices	VI	Numerical value	Magnification	Picture recording	Treatment steps	Activity assessment
QLF®	+	+	+	+++	+	+/–
DIAGNOcam®	+	–	++	+++	–	–
DIAGNOdent®	–	+	–	–	–	–
VistaProof®	++	+	++	+++	?	+
Vistascan IX®		+	++	+++	?	+
Canary system®	+/–	+	+/–	++	–	+
SiroInspect®(FACE)	+	–	–	–	+	+
SoproLife®	+++	–	++++	+++	+++	+++

Currently, the majority of dental practices operate under a surgical model. Caries Management by Risk Assessment (CaMBRA) encourages a paradigm shift from this methodology to one based on a medical model of disease prevention and management.

Caries can be largely prevented in nearly all populations by encouraging a regimen of oral hygiene protocols that control the manifestation of the disease, or keep the oral environment in a state of balance between pathological and preventive factors. CaMBRA is an approach to caries management that uses evidence-based treatment decisions based on the caries risk status of the individual. If a patient's caries risk is assessed, then appropriate interventions that are consistent with CaMBRA clinical protocols are implemented in order to influence caries progression. An imbalance towards either pathological or protective factors will determine whether caries progresses, halts or reverses.

The principles of CaMBRA are modification of the oral flora to favour health; patient education and informed participation in preventing oral disease; remineralization of non-cavitated lesions of enamel and dentine/cementum; and minimal operative intervention of cavitated lesions and defective restorations.

At the dental visit, the practitioner will conduct a clinical exam to assess the caries status. On the basis of saliva tests (to determine bacterial levels) and a validated risk assessment questionnaire,[51] caries risk status will be determined as low, moderate, high or extreme high.[52]

The UCSF School of Dentistry has conducted a three-year study where the overall study objective was to provide clinical evidence that scientifically based caries risk assessment, in conjunction with aggressive preventive measures and conservative restorative treatment, resulted in a dramatic reduction in future caries incidence. The study group who received restorative treatment alone showed after a slight decrease, an increase in caries-causing bacteria over time, but the group who received restorative and preventive interventions combined showed a decrease. The intervention group had a statistically significantly 24% lower mean caries increment than the control group ($p = 0.020$). Overall, caries risk reduced significantly in intervention versus control over two years.[50]

Lasers for minimally invasive preparation and caries prevention

Lasers of the Erbium family (Er:YAG emission wavelength 2970 nm, ErCr:YSGG laser 2780 nm wavelength) are considered safe for ablation of dental hard tissues,[53–56] as well as for removal of composite resins.[57–59] Whether caries removal with lasers is as efficient as using a regular drill is up for discussion[60] but using lasers for instance in paediatric dentistry is widely considered as advantageous.[61] The ability of hard tissue lasers to reduce or eliminate vibrations, the audible whine of drills, microfractures, and some of the discomfort that many patients fear and commonly associate with high-speed handpieces has been described as impressive.[62]

High caries prevalence in occlusal pits and fissures has warranted the search for novel prevention methods. The capability of lasers to modify enamel surface properties has promised a new type of caries prevention therapy. Erbium lasers have been shown to produce acid resistance *in vitro*,[63] but currently there is no information available showing the clinical uses of those lasers for caries prevention.

Specific carbon dioxide (CO_2) lasers – wavelength 9.6 or 9.3 μm, short pulsed in the microsecond range – have been better studied for caries prevention. *In vivo* an 86% reduction in smooth surface demineralization following short-pulsed 9.6 μm CO_2-laser irradiation was recently reported.[64,65] In a consequent study using the International Caries Detection and Assessment System (ICDAS-II) and the Soprolife Light-Induced Fluorescence Evaluator, it was shown that irradiating fissures of second molars with this specific CO_2-pulsed laser markedly inhibited caries progression in pits and fissures in comparison to fluoride varnish use alone over 12 months. Soprolife evaluations confirmed the ICDAS results.[66] To achieve acid resistance of the fissure system of a tooth, the fissure and the adjacent enamel next to the fissure area is covered with the 9.6 μm CO_2-laser irradiation. The laser emits laser pulses with a repetition rate of 20 Hz (20 pulses per second), the laser spot size is roughly 0.8 mm and the laser is applied with an angulated laser handpiece. To achieve caries resistance, the goal is to irradiate each enamel spot with 20 overlapping laser pulses, resulting in a superficial temperature rise of roughly 800 °C (just below enamel melting) in an enamel layer of less than 100 μm thickness. The average treatment time for a molar fissure is around 1.5 minutes and results in driving out the carbonated phase from the typical natural carbonated hydroxyapatite. Getting rid of the carbonated phase changes enamel into the more acid resistant, less soluble hydroxyapatite. Adding fluoride immediately afterwards results in the even more acid resistant and least soluble fluorapatite. These short-pulsed CO_2-lasers will represent the next generation of hard tissue lasers for caries removal[67,68] as well as hard tissue cutting.[69]

Common clinical steps

Professional prophylactic cleaning

This step currently remains one of the most complicated. In fact an *ad hoc* diagnosis assumed that the deepest part of the groove was perfectly cleaned without injury to the infected enamel, providing an overview of an area around 0.1 mm wide in dry conditions. Without clear evidence, we simply limited our purposes to clinical advice. As the crystalline structure is highly unstable and the average width of the pits is around 0.1 mm, the use of sharp probe and burs is strictly forbidden, and cleaning with a rotating brush in combination with prophylactic paste could disturb the values ratio given by the different diagnosis devices. One reasonable clinical proposition is to treat with an air polishing device in conjunction with sodium bicarbonate (Kavoprophy®, AirNGO®, EMS® air flow handy). The use of slightly harder calcium carbonate powder (Pearl powder®, Acteon Satelec, France, Kavoprophy® prophy powder, Germany) is also advisable. Precautions are needed to reduce the overflow of the powder (high suction, dental dam set up). In case of a high-risk patient with no monitoring possibilities, the decision can be made to seal the groove. Sylc® powder (OSSpray, Abbottstown, USA) in this particular case selectively removed the infected enamel, but a special nozzle was needed due to the extreme hardness of the powder.[70,71]

In case 1 sandblasting was undertaken with a calcium carbonate powder (Fig. 5–13). In case 2 sandblasting was undertaken with a bioactive glass. (Sylc® powder) (Fig. 14–17).

Minimally invasive treatment type 1

Minimally invasive treatment type 1 (MIT1) encompasses all the dental techniques aimed at sterilizing/disinfecting (e.g. ozone therapy), remineralizing, reversing and sealing the carious process. Nowadays there are many products available, each with their own advantages and disadvantages (Table 8).[3]

The LIFEDT concept applied to treatment of enamel caries

The challenge is early diagnosis of enamel decay before cavitation occurs, and consequently to manage your clinical decision depending on the individual caries risk of the patient. A combination of the CaMBRA approach[41,42] and LIFEDT could certainly help to better understand this clinical approach (Table 9). Based

Fig. 7 Red fluorescence confirming the decay (ICDAS 5) (SoproCare®, Cario mode) (black arrows).

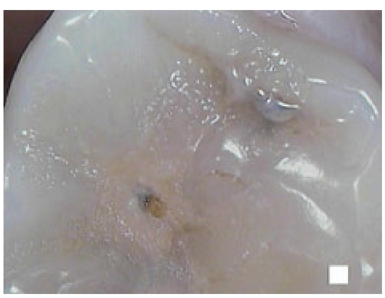

Fig. 5 Occlusal view, daylight mode before cleaning; dental plaque concealing possible decay.

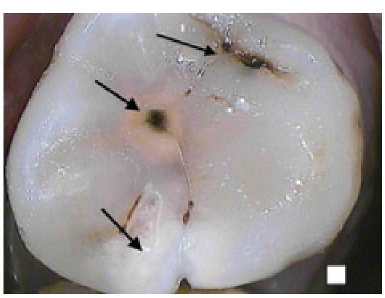

Fig. 6 View of the occlusal decay and the obvious proximal decay after cleaning (Pearl power, AirNGo system, Acteon, Bordeaux France, Soprocare®, daylight view) (black arrows).

Fig. 8 Illustration of the occlusal and proximal decay of the same tooth during preparation. (Soprolife®, treatment mode).

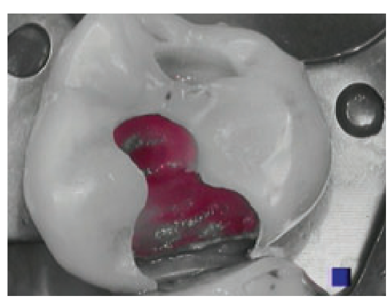

Fig. 9 The same tooth in caries mode during preparation (Soprocare®).

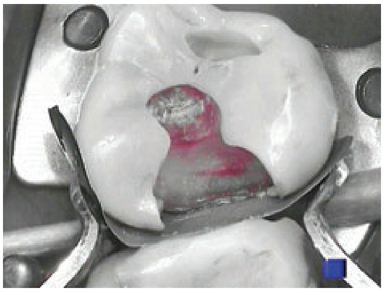

Fig. 10 End of the excavation steps of the occlusal and Class II area (caries mode Soprocare®).

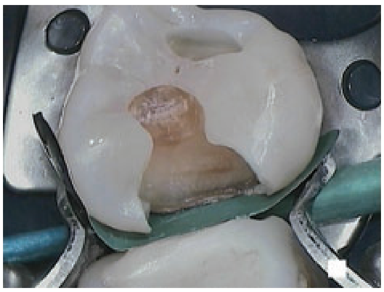

Fig. 11 The same tooth in daylight.

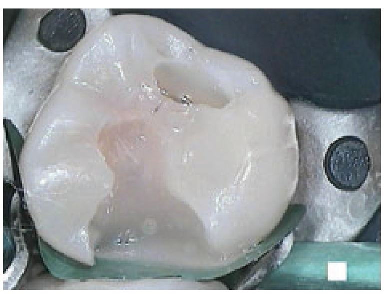

Fig. 12 Dentine substitute (3M, flow composite, V3 ring matrix, USA).

Fig. 13 Occlusal and proximal areas rebuilding (H*rI* composite, Micerium, Italy).

Fig. 14 Occlusal view. ICDAS[49] score 4 or 5. Old sealant visible. Soprocare® daylight mode.

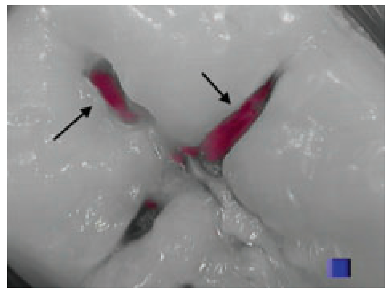

Fig. 15 Open pits after Sylc® sandblasting. Red signal revealing the dentine decay. Soprocare® caries mode (black arrows).

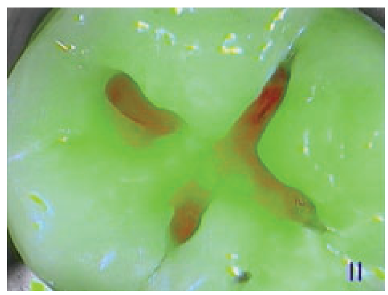

Fig. 16 Soprolife® view at the end point of excavation with Sylc powder. Red shadow revealed hard sclerotic dentine remaining.

Fig. 17 Occlusal restoration with a nanohybrid composite.

on daylight and fluorescence observations, coupled with the high magnification, a decision-making diagram is as follows. With a smooth surface, use of a polishing cup with prophylaxis paste which removes discolourations, plaque and polishes the tooth surface. Choose a fine grit, as the crystalline structure is highly unstable, to avoid causing any unnecessary abrasion of the tooth's structure and restoration surfaces. Some pastes contain fluoride and should be free of known allergens (e.g. Flairesse® prophylaxis paste, DMG, Germany).

Furthermore, the LIFEDT system does not address the issue of bacterial load. This can be determined using bacterial tests such as GC Saliva Check SM®, GC Plaque-check® + pH (GC, Tokyo, Japan), and

Table 8. Advantages and disadvantages of MIT1 with regard to the treated surface[3,26,27]

MIT1	Techniques	Advantages	Disadvantages	Diagnosis aided
Occlusal, vestibular, lingual and palatal surfaces	Varnish, MI paste plus, GC Tooth Mousse (GC, Tokyo, Japan). Ozonetherapy (Kavo, Biberach, Germany). Sealant application.	Easy application and protocol. Optimum aesthetic results. Reversible actions, non-iatrogenic.	Efficiency with regard to the caries risk assessment and the sensitivity and specificity of the diagnosis aid. Efficiency doubtful for ozone.	Fluorescence/picture device: ++++ Fluorescence device: ++ Laser device: ++ Electric device: ++ Transillumination: +
Proximal surface	Varnish* MI Paste Plus*, GC Tooth Mousse* (GC, Tokyo, Japan). Icon* (DMG, Hamburg, Germany). *Needs accessible surfaces.	Application not so easy. Optimum aesthetic results. Reversible actions, non-iatrogenic.	Efficiency with regard to the caries risk assessment and the sensitivity and specificity of the diagnosis aid. Operator-dependent. New techniques proof to be confirmed for Icon. Accessible surfaces need to be strongly separated when using Icon.	Fluorescence/picture device: ++++ Fluorescence device: ++ Laser device: +++ Electric device: ++ Transillumination device: +++

Table 9. Combination of CaMBRA and LIFEDT in case of enamel lesions

Type of lesion	High risk	Low risk
Smooth surface enamel lesion. Active smooth surface showed blueish cast in diagnostic mode and looks rough and matt in daylight mode.	Professional prophylactic cleaning. • Brushing 2–3 times per day: 1.1% (5000 ppm) NAF toothpaste. Xylitol (6 g/day): chewable tablets. Application of fluoride varnish (5% NAF); recall every 3–4 months. Application of calcium phosphate–based paste (MI Plus® GC Tooth Mousse®, GC Tokyo, Japan). Mouthwash: 0.12% chlorhexidine: 1 minute every evening for 1 week per month. Dietary counselling.	Brushing 2–3 times per day with 1100 ppm fluoride toothpaste); Patient recall every 6 months. (Application of calcium phosphate-based, paste (optional). (MI Plus® GC Tooth Mousse®, GC Tokyo, Japan).
Pits or complex shape grooves. After cleaning: Suspicious grooves with fluorescence altered (red signal) from a healthy area. Code[4] 1–3 (Table 2)	LIFEDT Concept: If the diagnostic aided (fluorescence, laser, electric monitor) confirm groove fissuration and any variations in fluorescence, a sealant will be applied using a dental dam, due to effectiveness of brushing being impossible to monitor. (Note that red fluorescence of the grooves might be related with the activity of the decay).	Groove without modified fluorescence. Sealant and varnish are optional. Groove with modified fluorescence: a sealant is recommended.
Products available	Fluoride varnish: Fluorprotector® (Vivadent, Schaan, Leichtenstein), Flairesse varnish® (DMG, Germany).	Sealants: VOCO, 3M, Vivadent.

Cariscreen® (Oral Biotechnologies, Albany, OR, USA). In the presence of a high-risk oral ecology, any fissured groove and any modification in the natural fluorescence serves as an indication to implement the LIFEDT concept. Until the evidence of dentinal damage by caries is definitely diagnosed using radiography and other diagnosis aiding cameras, the LIFEDT concept, based on the work of Mertz-Fairhurst *et al.*,[72] recommends preventive sealing rather than a conventional irreversible mechanistic approach of drilling.[3,73] This approach also opens up new prospects in terms of monitoring restorations if a transparent sealant is applied (experimental sealant, Voco, Germany). Indeed, any suspicious variation of the tissue fluorescence around existing restorations should facilitate better diagnosis of recurrent caries.

The LIFEDT concept applied to treatment of dentinal caries

In terms of the MID philosophy, the minimally excavating technique entails evaluating the caries removal effectiveness (CRE) and minimal invasive potential (MIP) of the different available techniques for removing infected dentine (Table 10). Neves *et al.*[74] reported that rotary/oscillating caries removal may lead to over-excavation when combined with Caries Detector (Kuraray, Japan). Despite the original intention, the Er: YAG-laser aided by light induced fluorescence has been described as a non-selective caries removal technique. A tendency of under-preparation was observed with ceramic burs (CeraBur, KISM, Komet-Brasseler, Lemgo, Germany) and Cariex, an air scaler with

Table 10. LIFEDT concept for dentine[4,26,27]

Principle	First analyse a healthy area on the tooth concerned for use as a fluorescence reference during image processing and analysis
Active carious lesion	Visual signals in fluorescent mode • healthy dentine: acid green fluorescence • infected dentine: green-black fluorescence • infected/affected dentine: bright red fluorescence. This tissue is fairly easily eliminated with a manual excavator. **Clinical considerations** In case of high caries risk-applicable to all lesion types, active or arrested, consider the following: • according to depth of lesion: the residual septicity of the dentinal structure is the key factor in the general practitioner's thinking. Opt for provisional fitting of a conventional glass ionomer, such as Fuji VII® (GC Japan). • perform permanent treatments once the carious disease has stabilized. **Permanent treatments** In case of low caries risk-applicable to all lesion types, active or arrested, consider the following: • using a dental dam is essential • favour manual excavation over mechanical rotary caries removal • disinfect the dentine wound with a 5% aqueous solution of chlorhexidine or use the PAD® technique (photo of activated disinfection with tolonium chloride solution)[55] • if the area is accessible and enables a leak-tight contact, ozone disinfection therapy is feasible • favour fitting a bioactive dentine substitute, such as resin-modified glass ionomer, especially if the enamel edges have disappeared[21] • in case of a eugenol-based dressing, opt for an amalgam restoration • in case of a temporary dentine substitute such as conventional glass ionomer cement, consider the fitting time and the bonding of the adhesive/composite system used with this material. A change in fluorescence could help with this decision • consider whether it is necessary to use antiseptic enamel-dentinal adhesives (e.g. Clearfil Protect Bond®, Kuraray, Japan) • consider the choice of the most appropriate adhesive for the residual dentine structure (total etch, self etch, etc).
Arrested lesion	**Visual signals in fluorescent mode** • healthy dentine: acid green fluorescence • infected dentine: green-black fluorescence • infected/affected dentine: dark red fluorescence. This tissue is more difficult to eliminate with a manual excavator. Surgical treatment of this tissue by rotary milling (tungsten carbide or ceramic) under spray is feasible • abnormal dentine at end of excavation: light green-grey fluorescence with systematically persisting shady pink fluorescence at the bottom of the preparation, opposite the pulpal wall. **Clinical considerations** • according to the depth of the lesion: the residual septicity of the dentine structure and activity of the disease are no longer the key factors in the general practitioner's thinking. Using a dental dam is essential • disinfect the dentine wound with a 5% aqueous solution of chlorhexidine or use the PAD® technique[55] (photo-activated-disinfection with tolonium chloride solution) • if the area is accessible and enables a leak-tight contact, an ozone disinfection therapy is feasible • fitting a bioactive dentine substitute such as resin-modified glass ionomer is balanced with the injection of a chemo-polymerizing composite, especially if there are persisting enamel edges around the cervical border of the preparation • in case of a eugenol-based dressing, opt for an amalgam restoration • temporary fitting of a conventional glass ionomer is not absolutely necessary • consider the choice of the most appropriate adhesive for the residual dentine structure (total etch, self etch, etc).
Mixed lesions	In case of a mixed lesion (active and arrested), the carious lesion should be considered active in its entirety.

coupled tungsten-carbide oscillating tips. Finally, the tungsten-carbide bur use gave good results when used alone, and the best technique with regards to CRE and MIP remained the chemomechanical methods with the new experimental enzyme-based caries-removal gels (exp. SFC and VIII, 3M-ESPE, Seefeld, Germany), coupled with a metal spoon excavator which is not yet on the market. Time use should be more precisely evaluated with these kinds of techniques. Specifically removing the layer of carious dentine which is rich in bacteria, unremineralizable and has necrotic tissue remaining on its surface, remains a challenge, depending on the CRE and MIP concept.[74–77] The end point of the excavation process still remains hazy. The use of caries dyes can be useful for training purposes[78] but in clinical practice will definitely lead to unnecessary removal of sound tooth structure. Use of chemomechanical methods of caries removal is also increasing but the main drawbacks are time consumption and a tendency of under-preparation.[74] Concerning the fluorescence aids for caries excavation device (FACE®), Lennon *et al.* in their study[16,17] on FACE® versus caries detector and conventional caries excavation concluded that excavation using FACE® is more effective than conventional excavation in removing infected primary dentine and superior to caries detector dyes and chemomechanical excavation. Among the different caries detection devices, only those combining fluorescence signals with pictures are useful. Soprolife®, unlike DIAGNOdent® (KaVo, Biberach, Germany), provides an overall image of the clinical situation instead of a point-by-point measurement. DIAGNOdent® has been described as having a good level of sensitivity and low specificity, but it was more useful for caries diagnosis than for caries discrimination, and there were false-positive signals. Moreover, a recent study[15] has revealed that measurements from DIAGNOdent® were not strongly correlated with the required depth and volume of the cavity preparation. Authors concluded that appropriate visual examination training may provide similar results without the need for additional equipment.

The LIFEDT concept applied to occlusal decay

When evaluating occlusal fissure areas with Soprolife® in daylight and fluorescent modes, three clinical forms (Code 1, 2, 3) were previously described[26,27] dependent on information given by the fluorescence signal and the magnification. In a more recent study, Rechmann *et al.*[4] gave an accurate score description from zero to five for daylight and fluorescence mode (Table 2). Discussions about an appropriate cut-off point to determine an operative intervention deserve our attention, but it seems reasonable to treat from a score of 4/5 depending on the width, depth and cavity shape, as well as the fluorescence information retrieved. The sensitivity and specificity of each device will shift this cut-off point; therefore, the principle is first to gently clean the pits (applicable for all devices) and then observe any modification of the structure and shape of the pits in daylight and fluorescence mode. Systems giving caries scores with no visual inspection can be used complementarily. (Illustrations in Fig. 5–9 and Fig. 14–17. See also Tables 11 and 12.)

The LIFEDT concept applied to approximal cavities

The major difficulty in the approximal tooth area is associated with the possible presence of a caries lesion in the approximal zones. Even though bitewing radiographs give relatively good information, mistakes are sometimes unforeseeable (Fig. 18). In some clinical situations, we propose separating the teeth as far as possible using powerful plastic wedges. When using the Soprolife® camera in daylight mode and fluorescent mode it might be possible in most cases to view cavitations (if present). Transilluminations with DIAGNOcam® could also be helpful. The presence of cavitation and/or a lesion involving the middle third of the dentine contraindicates the use of the resin infiltrant technique and means that the tissues must be prepared mechanically. To objectively balance your clinical decision between MIT1 and MIT2 in proximal areas, a combination of X-rays, fluorescence, laser and magnification could help to achieve better identification (Tables 11 and 12.)

Treatment decision making

In preventive care decision making, depending on the extent of demineralization, suspicion of the enamel breakdown and lesion accessibility, the clinical treatment choice should be balanced between monitoring, application of fluoride varnish and sealing with resin infiltrant (Icon®, DMG, Germany) (Tables 8 and 9). Operative decision making in regards to the marginal crest should take into account the traditional Class II restoration, tunnel or slot preparation. When the marginal crest is non-recoverable, the fluorescence emission is blueish with a very low green emission (Fig. 22). In that particular case, only traditional Class II preparation is recommended.

Approximal caries lesions without cavitation

MIT1 illustration of a sealant infiltration (resin infiltrant Icon®, DMG).

The presence of cavitation and/or a lesion involving the middle third of the dentine (from D2 onward in terms of caries extension) contraindicates the use of Icon, and means that the tissues must be prepared mechanically.

Table 11. Advantages and disadvantages between sonic and ultrasonic cavity preparation system in case of slot cavity and minimally invasive Class II preparation[3]

MIT2	Ultrasonic	Sonic	Preparations
Advantages	Preservation of the adjacent proximal surface. Preservation of the marginal ridge (slot and tunnel cavity). Uses the same ultrasonic handpiece as for periodontal scaling. Initial penetration with diamond burs. The cavity is required less often. Natural aesthetics preserved.	Preservation of the adjacent proximal surface. Preservation of the marginal ridge (slot and tunnel cavity). Uses the same sonic handpiece as for periodontal scaling. Natural aesthetics preserved.	Tunnel and slot preparations. End steps of minimally invasive Class II preparation. Bevelling steps.
Disadvantages	Information concerning the potential to create cracks due to ultrasonic vibrations and their clinical outcomes is not provided by the manufacturer. The outer carious dentine is better removed with a round steel bur mounted on a low speed motor or with a manual excavator. Proximal surface is more difficult to preserve than with the sonic device with regard to the effectiveness of the ultrasonic vibrations. The effectiveness of the device depends on the hardness of the dental tissue. Operator-dependent.	Requires specific type of water cooled handpiece. The effectiveness of the device depends on the hardness of the dental tissue. Operator-dependent.	Efficiency with regard to the caries risk assessment. Operator dependent. Perfect filling remains difficult to control with slot and tunnel cavities. The thickness limit of the marginal ridge remains unknown for tunnel and slot cavities.

Table 12. Different types of MIT1 (no preparation except tissue conditioning) and MIT2 with minimal preparation[3,57]

Minimally invasive technique	Type 1: No preparation except tissue conditioning	Type 2: Minimal preparation
Occlusal, vestibular, lingual or palatal surfaces	Fluoride and chlorhexidine varnish (Vivadent, Voco etc.), Glass ionomer varnish (3M, ESPE) MI Paste Plus® and GC Tooth Mousse® (GC, Tokyo, Japan) Ozonetherapy coupled with remineralization solution (KaVo, Biberach, Germany). Sealant application	Reversed caries process technique (glass ionomer dentine substitutes, stepwise techniques). Minimally invasive preparation with micro-burs or other techniques (air abrasion, laser, sonic or ultrasonic inserts, adhesive preparation).
Proximal surface	Fluoride and chlorhexidine varnish (Vivadent, Voco etc.), Glass ionomer varnish (3M, ESPE) MI Paste Plus®, GC Tooth Mousse® (GC, Tokyo, Japan) Resin Infiltrant: Icon® (DMG, Hamburg Germany)	Reversed caries process technique (glass-ionomer dentine substitutes, stepwise techniques) with minimally invasive Class II preparation. One-step minimally invasive Class II preparation with micro-burs or other techniques (air abrasion, laser, sonic or ultrasonic inserts, adhesive preparation). Slot and tunnel cavities with suitable sonic inserts. (Caries scale D1-D2 with cavitation).
Diagnosis and treatment aids	Fluorescence: +++; Laser: +++; Electric: ++	Fluorescence/picture: ++++; Transillumination: ++; Laser: -Electric: -

Clinical steps in brief

The following steps should be followed[3]: (1) demineralize the non-cavitated caries with hydrochloric acid for 2 minutes (Fig. 26), followed by a water rinse for at least 30 seconds; (2) dry the area with an Icon dry syringe (99% ethanol) solution (Fig. 30), followed by drying with oil- and water-free triplex air; (3) infiltrate the suspicious area with an Icon® infiltrant syringe and a suitable approximal tip (Fig. 28). The material will be delivered only on the green side of

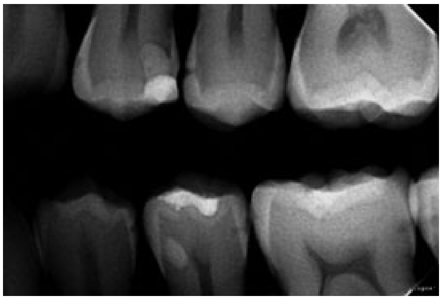

Fig. 18 Proximal mesial decay on the second upper premolar. Minor cavitation of the enamel layer is visible.

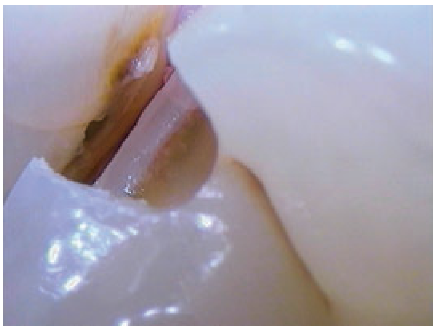

Fig. 19 Soprolife® daylight picture in macro focus mode of the same tooth. The clinical view showed a more complex situation with a plaque stagnation area, a large demineralized enamel area, and two points of entry with one cavitated.

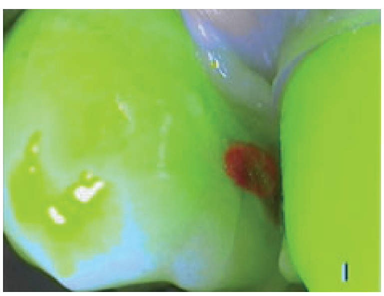

Fig. 20 Early proximal decay with a visible enamel crack. Soprolife® diagnosis mode.

Fig. 21 Enamel cracks and visible enamel breakdown detected due to the high magnification on a proximal distal area.

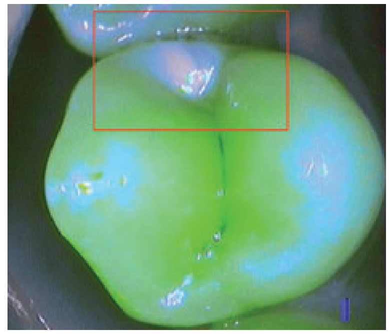

Fig. 22 Blue marginal crest revealing complete destruction of the underlying dentine (red rectangular).

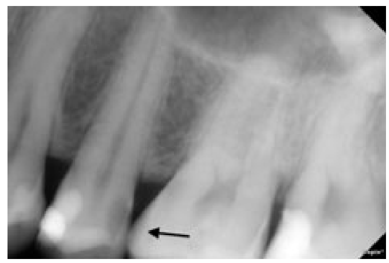

Fig. 23 Enamel decay (black arrow) on mesial side of the first upper molar face the distal one of the second upper premolar. Poor X-ray information.

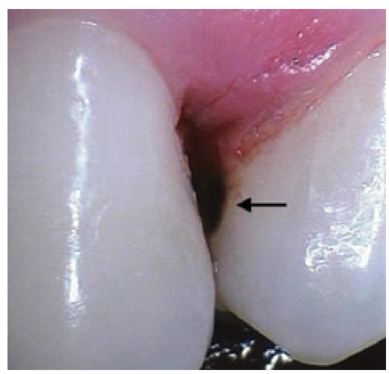

Fig. 24 Front view of proximal decay of a demineralized area of enamel (daylight mode Soprolife®).

the approximal tip; (4) light cure the resin infiltrant for 20 seconds, on the occlusal, vestibular and palatal sides, power required 1200 mW/cm^2) (Fig. 29).

Minimally invasive treatment type 2

Minimally invasive treatment type 2 (MIT2)[3,80,81] involves a series of specific tools, including sonic and ultrasonic inserts, to prepare the relevant tooth minimally without damaging the adjacent tooth, even in the case of Class II preparations. The systematic application of a

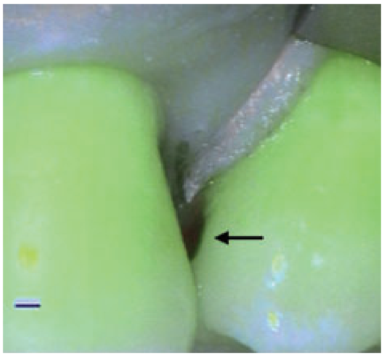

Fig. 25 Confirmation of the green signal fluorescence modification to dark signal (dark arrow) (diagnostic mode Soprolife®).

Fig. 26 Application of hydrochloric acid for 2 minutes with the adapted celluloid matrix.

Fig. 27 Rinsed and dried with alcohol.

metal matrix (Fenderwedge, V ring matrix, USA) before preparation in order to preserve the adjacent surface is recommended even for slot or Class II preparations. The advantages and disadvantages of the ultrasonic system are shown in Table 11. However, these minimal preparations also require systematic use of micro-instrumentation sets developed for minimally invasive dentistry (Kotschy set, Hu-Friedy, Chicago, USA).

Ultrasonic devices

The ultrasonic systems consist of various autoclavable aluminium cassettes and a selection of semi-circular

Fig. 28 Injection of the resin infiltrant through the microporosities of the celluloid matrix.

Fig. 29 Final checking of the nanohybrid composite and the resin infiltration.

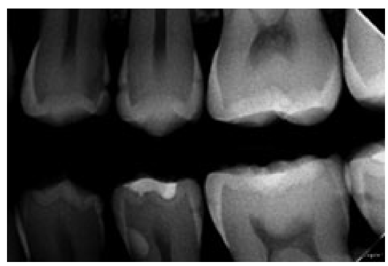

Fig. 30 Numeric bitewing X-ray (Sopix 2®, Sopro, la Ciotat, France).

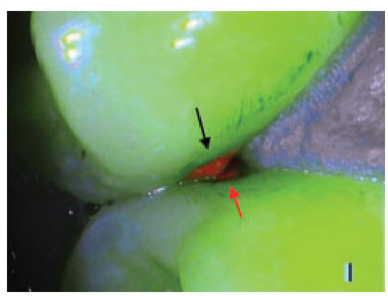

Fig. 31 Palatal view in focus macro-mode (Diagnosis mode, Soprolife®). Black arrow showing the plaque stagnation area, and red arrow showing the visible cavitation of the distal area.

metallic inserts of different types, with one inactive smooth face free of diamond abrasive.[80,81] The inserts are mounted in a water-cooled ultrasonic handpiece

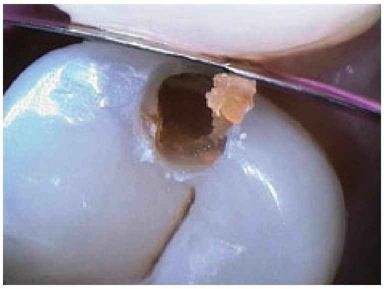

Fig. 32 View of the preparation in daylight mode.

Fig. 33 View of the preparation in fluorescent mode.

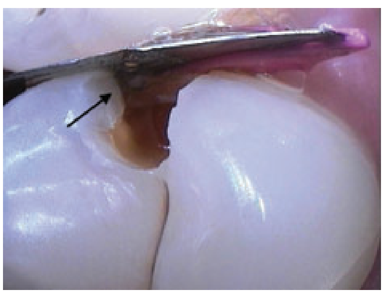

Fig. 34 Observation of the vestibular spreading of the decay under magnification (black arrow).

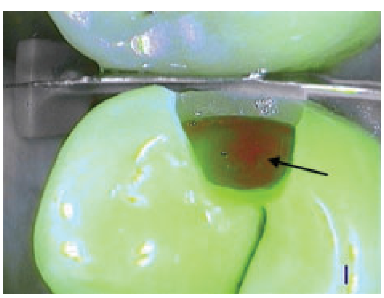

Fig. 35 End of the excavation step. Red fluorescence shadow of sclerotic dentine remained (black arrow).

which emits ultrasonic vibrations (above 20 000 Hertz) (Table 11).

Sonic devices

The sonic insert system is also ergonomically designed.[80,81] It consists of an autoclavable aluminium

Fig. 36 Proximal area rebuilt with a nanohybrid composite (Empress® composite L shade, Vivadent, Schaan, Liechtenstein).

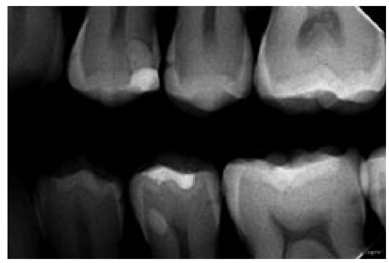

Fig. 37 Numeric bitewing checking (Sopix 2®, Sopro, La Ciotat, France).

cassette and a selection of different semi-circular metallic inserts with one inactive smooth face free of diamond abrasive. The inserts are mounted in a water-cooled handpiece (Kavo® 2003, KaVo Biberach, Germany) that emits sonic vibrations (Power 2; 6000 Hertz, oscillation amplitude: 160 μm). The inserts are selected by the defined angularity of each insert, and the working proximal site (mesial or distal surfaces) (Table 11).

Clinical illustrations

Case 1 minimally invasive Class II preparation

Illumination of the marginal ridge in fluorescence mode gives information about the dentine structure beneath the enamel layer (Fig. 30–37). If the medium third or inner third of the dentine is decayed, the marginal crest reveals a blue reflection most of the time (Fig. 22). In that case, conventional Class II preparation is beneficial.

Case 2 slot preparation[80,81]

If the fluorescence of the marginal crest remains green, slot or tunnel preparation (Fig. 38–48) can be considered (Fig. 40) subject to the presence of enamel cracks, the residual thickness and the operative difficulties. Fluorescence can also give information about the direction of the decay's point of entry (Fig. 40 and 41). That greatly influences your clinical decision and the operative steps.

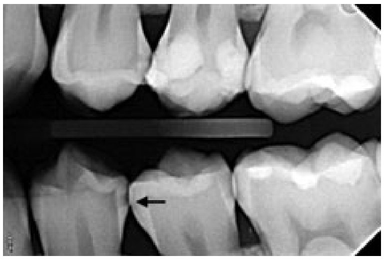

Fig. 38 Bitewing X-rays showing the distal proximal decay on the first lower molar (black arrow).

Fig. 39 Orange-brown shadow revealing the decay through the marginal crest thickness (black arrow).

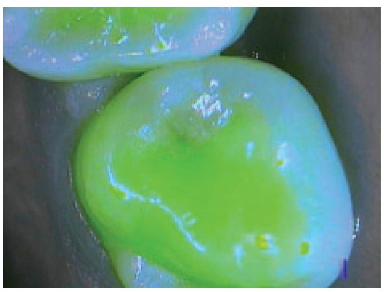

Fig. 40 Fluorescence of the marginal crest appears similar to the healthy one.

Fig. 41 Vestibular point of entry with a dental plaque accretion.

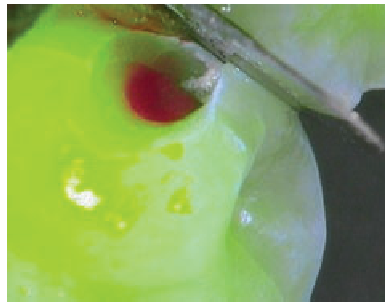

Fig. 42 Infected decay in the heart of the slot preparation looking red when light in fluorescence mode.

Fig. 43 Sonic or ultrasonic diamond insert in action (semi-circular insert, Komet®, Excavus®, KaVo®).

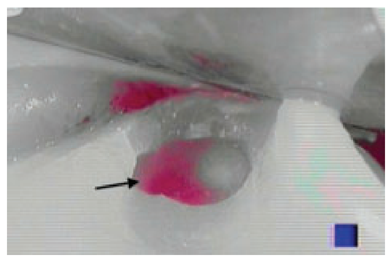

Fig. 44 Half-way checking of the excavation with the Soprocare® mode caries. Part of the infected dentine still needed to be removed (Soprocare® view, caries mode).

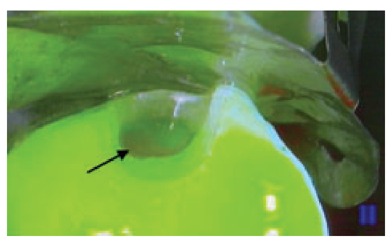

Fig. 45 End step of excavation of the infected dentine. Red fluorescent dentine was partially removed with the combination of ceramic burs (Komet®) and sharp hand excavator.

Operative steps for slot preparation

Slot preparation involves the following steps: (1) fit a protective metal matrix, and use a micro-bur (circular microburs, Komet, France); (2) prepare the slot cavity at constant pressure using the sonic or ultrasonic diamond insert; (3) fit the dental rubber dam, remove the infected dentine using a Kotschy micro-excavator, monitoring with a Soprolife® camera, and disinfect the dentine (Tubulicid® solution, Schorndorf,

Fig. 46 Possible sterilization of the affected dentine with tolonium chloride application for 60 seconds and light activated (60 seconds irradiation) (PAD® or photoactivated-disinfection, Dentfotex, UK).[55]

Fig. 47 Lingual view of the slot preparation filled with a hybrid glass ionomer (Fuji II LC®, GC, Japan) one week later.

Fig. 48 Final check, numeric bitewing X-ray (Sopix 2®, Acteon; Bordeaux, France).

Germany); (4) form a metal matrix and inject hybrid glass-ionomer cement; and (5) photo-polymerization (3 x 20 seconds), polishing and application of a fluoride varnish.

CONCLUSIONS

The apparent simplicity of these techniques is, in most clinical situations, counterbalanced by implementation difficulties and by operating conditions which are much more complex than they appear. Without the different diagnostic and treatment aids, as described, the work could be even more difficult than expected. Nevertheless, the objectives of preserving the natural tooth structure are achieved by preservation of the enamel surface for MIT1 intervention and with preservation of the marginal ridge for MIT2 interventions, if a slot cavity could be prepared. Of course longevity of these restorations is ensured simply by working conscientiously, applying the LIFEDT concept and using a dental rubber dam for instance, but would be better accomplished by also applying CaMBRA principles. Nevertheless, more invasive treatments can successfully be delayed by minimal intervention dental therapies. Engaging a fluorescence caries detection camera in clinical cases providing a magnification power of more than 50 demonstrated its usefulness and confirmed that without visual aid the operator reduced his own sensitivity and specifity during the visual inspection. Combining the ultraconservative, restorative approach (which is considered micro-invasive) with a substantial caries risk assessment and caries management with remineralization programme (CaMBRA) may provide therapeutic benefits and will significantly reduce both long-term restorative needs and costs, thus complementing the overall concept of MID.

DISCLOSURE

The authors have no conflicts of interest to declare.

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