Technology-enhanced caries detection and treatment options

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_Abstract

Here we present a case report illustrating technology-enhanced caries detection and treatment systems on occlusal surfaces during a 26 month follow-up. The use of ozone therapy and a laser-induced fluorescence device on incipient occlusal caries lesions in a 25-year-old woman is described. The utilisation of the ozone therapy monitored by the laser-induced fluorescence device enabled an alternative and comfortable treatment for incipient caries lesions on occlusal surfaces. Thus, technology-enhanced caries detection and treatment systems are helpful tools during clinical practice.

Figs. 1a–c_Baseline clinical aspect of the incipient caries lesions on tooth 16 (Fig. 1a), tooth26 (Fig. 1b) and tooth 46 (Fig. 1c). Note that all teeth presented brown and white opacities on the fissures.

Fig. 2a_Laser-induced fluorescence device (DIAGNOdent).

Fig. 2b_LF reading using tip A for occlusal surfaces.

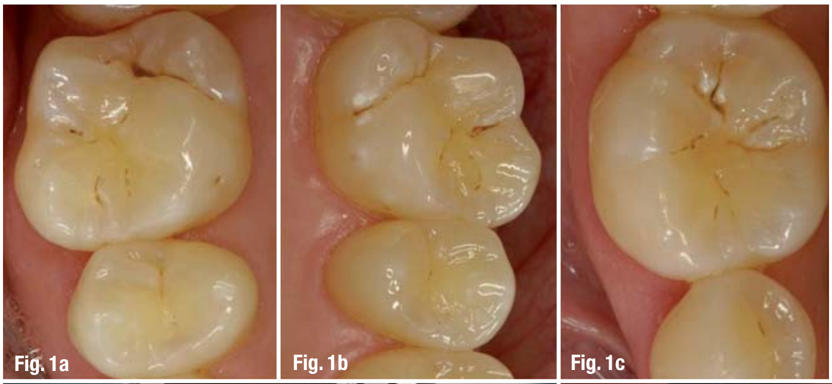

Fig. 1a Fig. 1b Fig. 1c

Fig. 2a

Fig. 2b

_Introduction

Although the prevalence of dental caries in children has declined in the past several decades, there has been a continuing increase in occlusal caries. This fact may be explained by the changes in caries pattern and progression. Additionally, this may be due to the increased use of fluoride and its superficial remineralisation, which seems to delay the cavitation (Strassler & Sensi 2008). In this way, incipient occlusal caries have become more difficult to detect.

The difficulty in diagnosing incipient caries has stimulated the development of new detection methods. Recently, new methods have become available as adjuncts to traditional methods, such as the fluorescence-based devices. These are based on the phenomenon that caries lesions fluoresce more strongly than sound tissues when stimulated by light at specific excitation wavelengths (Hibst et al. 2001, Bader & Sugars 2004). The most common laser-induced fluorescence device for caries detection used in dentistry is the DIAGNOdent (LF, DIAGNOdent 2095, KaVo, Biberach, Germany). This device emits a red light at 655 nm and quantifies the fluorescence from bacterial porphyrins and other chromophores present in caries lesions (Hibst et al. 2001). The changes in the fluorescence intensity are numerically quantified and translated in to values ranging from 0 to 99,

Fig. 3a_Ozone device (HealOzone)
Fig. 3a_Ozone gas application after carefully drying the occlusal surface. Note that the silicon cup tightly seals the covered area.
Fig. 4a_Clinical aspect of the incipient caries lesion on tooth 46 at baseline.
Fig. 4b_After 2 months.
Fig. 4c_After 26 months of follow-up. Note that the lesion's characteristics and severity changed over time, indicating that the treatment is effective.

according to the lesion's depth. This can be used to help clinicians decide whether a tooth should be restored (Young 2002). The device has been used as an auxiliary to detect and quantify mineral loss in caries lesions on smooth and occlusal surfaces, presenting good reproducibility and accuracy (Lussi et al. 1999, Lussi et al. 2001, Mendes et al. 2006, Rodrigues et al. 2008, Diniz et al. 2009).

It is important to point out that the management of dental caries is based on appropriate detection of pathological changes and, consequently, on the correct diagnosis to provide the best treatment for each patient (Tranaeus et al. 2005).

Recently, a novel concept for the treatment of dental caries using ozone gas as a potent microbicide has been introduced (Baysan et al. 2000, Baysan & Lynch 2004, Dähnhardt et al. 2006, Baysan & Beighton 2007). Ozone is a gas that quickly kills microorganisms by oxidative degradation of the unsaturated fatty acids in the cell wall (Dähnhardt et al. 2006). The device delivers ozone, through a hand piece, directly to the carious lesion in a concentration of 2,100 ppm with a changeover of 300 times per second. A silicon cup is able to tightly seal the covered area (Baysan et al. 2000). Previous reports have assessed the effect of ozone gas on occlusal caries, non-cavitated occlusal caries and primary root caries, showing significant reductions in the number of microorganisms (Baysan et al. 2000, Brazzelli et al. 2006, Baysan & Beighton 2007). However, the inhibitory effect of ozone in the caries process is discussed and controversial (Hauser-Gerspach et al., 2009; Kronenberg et al., 2009).

To date, there are some clinical studies evaluating improvements in the clinical status of non-cavitated occlusal caries and root caries after ozone therapy monitored by the laser-induced fluorescence device (Huth et al. 2005, Baysan & Lynch 2007). This clinical report illustrates that the application of ozone therapy (and monitoring using the laser-induced fluorescence device) on incipient caries on occlusal surfaces in a young woman during a 26-month follow-up.

_Case Report

A 25-year-old Caucasian woman was referred to the clinic of the Preventive, Restorative and Pediatric Dentistry department of the Dental School of Bern, Switzerland, presenting incipient caries lesions.

During the clinical interview, the patient reported that she presented a normal systemic status. The caries risk assessment indicated that she was at low risk.

Visual examination was performed by direct visualisation of the teeth with the aid of a light reflector and a 3-in-1 air syringe. The patient presented incipient caries lesions on the distal fossae upper right first molar (16), on the distal fossae upper left first molar (26) and on the central fossae lower right first molar (46) (Fig. 1). The visual and tactile characteristics observed were the presence of brown and white opacities and roughness on the fissures, indicating caries activity.

Bitewing radiographs were taken and then analysed using an X-ray viewer. No radiolucency was observed in the occlusal surfaces.

Based on clinical and radiographic observations, and considering anamnesis data, the treatment proposed was ozone therapy application (to reduce the microflora in the lesion) monitored by laser-induced fluorescence readings. The patient was instructed with respect to the maintenance of her oral hygiene. An informed consent contract was signed by the patient agreeing with the treatment.

The laser-induce fluorescence device used was the LF (DIAGNOdent 2095; KaVo, Biberach, Germany). The occlusal surfaces were measured ac-

Fig. 5a_Clinical aspect of the incipient caries lesion on tooth 26 at baseline.
Fig. 5b_After 26 months of follow-up. Note that the lesion's characteristics, such as smoothness and brightness, indicate caries inactivity.

cording to the manufacturer's instructions (Fig. 2). The device was first calibrated using a ceramic standard and then calibrated on the buccal surface of the right permanent central incisor. For measurements, tip A for occlusal surfaces was used. The device was moved through the entire occlusal surface until the highest value was obtained (peak value).

The ozone device used was the HealOzone delivery system (Oz; KaVo, Biberach, Germany). Ozone was applied on each tooth at room temperature according to the manufacturer's instructions (Fig. 3).

In each session, the occlusal surface of each tooth was cleaned for 10 s with a water-powder jet cleaner (PROPHYflex II, KaVo, Biberach, Germany) and sodium hydrogen carbonate powder. Then the caries status was measured by the LF device, and ozone was used after carefully drying the occlusal surface. The visual characteristics of the lesions were evaluated and considered as gold standards during the monitoring. The 26 month follow-up was performed according to Tab. 1. The LF device was checked and calibrated before each session. The ozone device was also checked on a regular basis. During the first recall visit, it was observed that the laser-induced fluorescence readings were lower than the baseline readings, indicating that 40 s of ozone therapy in each tooth was effective. However, after 10 months of follow up, the laser-fluorescence readings were higher than the baseline readings. In view of this fact, the time of the ozone therapy was increased to 80 s. After 26 months of follow up, a good response to the treatment was observed by the changes in clinical severity and in the LF readings (Figs. 4 & 5).

_Discussion

Ozone therapy was introduced as a conservative alternative in the treatment of primary caries, resulting in the in vivo reduction of the number of microorganisms present in lesions by 99% (Baysan & Lynch 2005, Baysan & Lynch 2006). The purpose of ozone therapy is to reduce the microflora in the lesion, to increase its pH and to oxidise pyruvic acid to acetate and CO_2, which opens up "channels" within the dentin to allow the penetration of calcium, phosphate and fluoride ions. This makes remineralisation of the demineralised hard tissue possible (Dähnhardt et al. 2006, Hodson & Dunne 2007).

A significant reduction in the clinical status of small and non-cavitated occlusal caries lesions after ozone therapy has been reported (Huth et al. 2005). In the present case, we clinically observed that the incipient lesions arrested after 26 months of follow-up, indicating that ozone therapy remineralised lesions over time. However, the treatment adopted in this case was better achieved when the ozone therapy was applied for 80 s on each tooth compared to 40 s. Polydorou et al. (2006) evaluated the antibacterial activity of 40- and 80-s HealOzone application. The authors concluded that the 80 s ozone application is a very promising therapy for eliminating residual microorganisms in deep cavities.

This case report shows it is possible to treat incipient caries lesions using an ozone-delivering device monitored by laser-induced fluorescence. The treated caries showed lower readings com-

Tab. 1_Laser-induced fluorescence (LF) readings and ozone therapy (Oz) application time for each session during a 26 month follow-up.

Tooth	Baseline		2 months		4 months		10 months		12 months	
	LF	Oz	LF	Oz	LF	Oz	LF	Oz	LF	Oz
16	17	40 s	18	40 s	11	40 s	19	80 s	-	80 s
26	30	40 s	18	40 s	22	40 s	38	80 s	-	40 s
46	19	40 s	12	40 s	20	40 s	19	80 s	-	40 s

Tooth	15 months		17 months		20 months		24 months		26 months	
	LF	Oz	LF	Oz	LF	Oz	LF	Oz	LF	Oz
16	15	80 s	-	80 s	20	80 s	20	80 s	4	-
26	17	80 s	-	80 s	38	80 s	23	80 s	4	-
46	16	80 s	-	80 s	16	80 s	14	80 s	10	-

pared to the baseline, indicating that the ozone therapy was successful. At the first recall visit, the LF readings were substantially reduced for tooth 26 and 46. This is in accordance with Dähnhardt et al. (2006), who observed that the use of ozone gas results in an average reduction of 13 % of the laser fluorescence values immediately after ozone therapy.

In the present case, the clinical characteristics and severity of the carious lesions changed over time, indicating that the treatment was effective. Recently, an in vivo study compared the performance of the LF device to visual and radiographic examination (Diniz et al. 2009). The authors concluded that the LF device may be a useful complement to visual examination, and its diagnostic performance seems to be superior for dentin caries detection. The same result was also observed by a systematic review (Bader & Shugars 2004) that showed laser-induced fluorescence tended to be more sensitive than the visual method in detecting occlusal caries in dentin and less sensitive in detecting enamel caries. The case presented in this paper was monitored by laser-induced fluorescence as an adjunct to visual examination because the LF device is supposed to be an auxiliary method for occlusal caries detection.

It is also important to consider that confounding factors might contribute to false-positive laser-induced fluorescence readings in clinical practice, such as the presence of stains, calculus, hypoplasia, polishing pastes and filling materials (Neuhaus et al. 2009). For this reason, a prophylaxis procedure was done on the occlusal surface of each tooth in each session to avoid possible false-positive readings.

While in this case report it was possible to monitor the caries status after ozone therapy by laser-induced fluorescence, there are some important aspects that clinicians should consider regarding this procedure. For instance, ozone has not been proven superior to other clinical approaches in caries management, such as fluoride or chlorhexidine, sealants, and stepwise excavation (Hodson & Dunne 2007). It may work better than these approaches, work well in combination with these approaches, or may prove to be entirely unnecessary (Hodson & Dunne 2007). In a systematic review of the literature by Rickard et al. (2004), there was no reliable evidence that the application of ozone gas to the surface of decayed teeth stops or reverses the decay process. The authors emphasised the need for more evidence of appropriate strictness and quality before the use of ozone can be accepted into primary dental care or can be considered a viable alternative to current methods for the management and treatment of dental caries. Additionally, the laser-induced fluorescence device should be considered as a second opinion because, to date, there is no method available that is completely reliable.

_Conclusions

The utilisation of ozone therapy monitored by laser-induced fluorescence enabled an alternative and comfortable treatment for incipient caries lesions on occlusal surfaces. However, the ozone therapy parameters and cost effectiveness is unknown. It should be recommended to increase the exposure time during the ozone therapy to achieve a better outcome. In addition, the laser-induce fluorescence device cannot be considered a standard diagnostic tool by itself. It should be used as an adjunct to the traditional methods, especially considering important patient factors, such as caries risk, caries activity, oral hygiene, diet and fluoride supplements.

_References

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Editorial note: The whole reference list can be requested from the editorial office.

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