The phenomenon of fluorescence is more often used in dentistry, based on the concept of both prevention and comprehensive patient diagnostics. The article presents the possibilities of using fluorescence generated by a 405 nm laser in conservative dentistry, periodontology and diagnostics of mucous membrane lesions.

The primary objective of diagnostics is to identify the patient’s claim to a dentist and to determine appropriate treatment, adequate to the diagnosis. Diagnostics in the dentist’s office is mainly based on the standard visualising methods with the use of a mirror and a conventional or a periodontal probe. Practitioners use X-rays for this purpose equally often. However, it causes a lot of problems and seems to be challenging to make a correct diagnosis, as traditional methods are not sufficient to accurately assess to proximal surfaces of teeth, subgingival deposits of calculus or the nature of lesions on the mucous membrane. There is a need for additional diagnostic methods, especially in that cases where it is not possible to take an X-ray (pregnant women, small children).

The optical methods based on the application of ultraviolet light, described by Stübel for the first time in 1911, are now gaining increasingly more recognition, mainly due to the lack of invasiveness and high sensitivity. Fluorescence testing is a modern diagnostic technique and is used in dentistry to detect carious lesions, tartar deposits and bacterial plaque, as well as lesions affecting the mucous membrane.

The phenomenon of fluorescence involves absorbing and simultaneously emitting photons with a lower energy level and a longer wavelength than excitation radiation. In the case of living cells, we are talking about autofluorescence related to the presence of endogenous chemicals capable of such emission (fluorophores). After absorbing light of a wavelength similar to ultraviolet, fluorophores are excited to a higher
energy level, and then – when returning to the previous level – they emit radiation of a longer wavelength (luminescence). Many natural substances, including minerals, fungi, bacteria, keratin, collagen and many other components of our bodies, are subject to auto-fluorescence, which is used in diagnostics. Regarding to the teeth this phenomenon is based on the presence of endogenous fluorophores in enamel and dentine. Numerous studies based on the phenomenon of fluorescence in dentistry have shown that there are no significant differences between the teeth of the maxilla and the mandible – all teeth in the same person have similar fluorescence intensity. However, a decrease in fluorescence, intensifying with age, has been observed in the case of changes in tooth structure in the form of increased dentine layer thickness and physiological closure of dental tubules with a simultaneous loss of enamel thickness.

This article describes the application of the phenomenon of fluorescence induced by a laser emitting a wavelength of 405 nm in dental diagnostics.

In everyday practice, this phenomenon can be used among other things for:
- diagnostics of demineralisation and caries, especially in fissures of molar teeth and on proximal surfaces
- detection of carious dentine during cavity preparation
- differentiation of necrotic teeth, fillings and prosthetic restorations
- detection of calculus, especially in periodontal pockets
- visualisation of cracks in enamel and teeth
- assessment of the condition of hygiene and effectiveness of tooth brushing in patients utilising orthodontic braces
- detection of residues of orthodontic adhesive around brackets and after its removal on the enamel, and as well the composite, used to splint the teeth after injuries
- detection of lesions invisible to the naked eye
- detection of potentially carcinogenic lesions on mucous membranes
- verification of the real margins of existing mucous lesions

The test should be carried out in a darkened room, and the laser tip should be positioned at a distance of about 10 cm from the tested object (Fig. 1, Fig. 2).

Diagnostics of demineralisation and caries, cavity preparation

According to the use of ultraviolet light, even small enamel porosity and initial stages of a carious defect can be diagnosed much more accurately than with standard methods.

Demineralisation spots within enamel transilluminated with the application of violet light have
a darker colour than the surrounding healthy tissues. In the case of bacterial contamination of the lesion, red light, characteristic of carious bacteria containing porphyrins, will be observed. This is very helpful during cavity preparation, as it allows the complete removal of carious dentine without excessive processing, and thus maximises the preservation of healthy tissues. However, it should be noted that the intensity of fluorescence in an advanced carious lesion is lower than if the lesion is at the initial stage. This is due to the fact that luminescence of porphyrins is absorbed by a brown-coloured tissue affected by caries or by a layer of reparative dentine (Fig. 3, Fig. 4, Fig. 5).

The fluorescence method can also be successfully applied to identify abnormalities of enamel mineralisation associated with its underdevelopment.

Fluorescence is also useful for fluorosis differentiation, which may have a similar structure and colour as initial carious lesions, but in ultraviolet light will vary in shape and location of the lesion.

**Differentiation of necrotic teeth, fillings and prosthetic restorations**

Prosthetic restorations do not exhibit fluorescence at all; teeth without vital pulp exhibit fluorescence to a much lesser extent, which allows for their easy differentiation during a standard examination.

Fluorescence enables the relatively easy detection of fillings placed in teeth. The perfect restoration material should exhibit fluorescence identical or very close to that of a natural tooth. However, composite fillings are characterised by different fluorescence depending on the type and amount of luminophores in their structure. Usually, these are molecules from periodic groups III, IV and V, having luminescence properties. Newer generations of composite materials contain substances that allow obtaining the required fluorescence, similar to the natural structure of the tooth, making them almost entirely invisible in ultraviolet light.

The use of 405 nm light is beneficial in everyday practice to diagnose leaking restorations, as well as to determine the quality of the junction between fillings and tooth structure, and microleakage. The red colour visible on the edges of the restoration will be a sign of bacterial contamination, and the necessity of replacement of the filling (Fig. 6, Fig. 7).

**Detection of dental plaque**

Owing to the ability to visualise deposits invisible to the naked eye, the use of 405 nm light allows for very fast, non-invasive and accurate periodontal diagnostics. Red fluorescence from mature plaque enables precise identification of supragingival calculus as well as deposits located deep in the periodontal
pockets. This is particularly important in the case of Actinomyces Actinomycetemcomitans and Fusobacterium Nucleatum, which are closely linked with periodontal diseases. This is because these bacteria show intense luminescence in red colour (Fig. 8).

The reuse of violet light after the scaling operation allows you to evaluate the correctness of its implementation

In the case of orthodontic patients with permanent braces, it is essential to maintain proper oral hygiene, which requires systematic motivation and controlling the effectiveness of the agents and methods used by the patients to remove the plaque from the teeth. Visualisation of dental deposits and plaque is an useful element in patient education. The application of a 405 nm laser does not require the use of plaque staining agents, making it more acceptable to the patient. Evaluation of tooth cleaning reveals inaccurately brushed areas as red/pink areas after exposure to laser light (Fig. 9).

Visualisation of cracks in enamel and teeth

Cracked and broken teeth are a diagnostic challenge due to the variety of non-specific symptoms reported by the patient. An adequate and early diagnosis can help to decide on further procedures. Fluorescence is an invaluable tool for detecting cracks in the enamel or crown or vertical root fractures (Fig. 10).

Detection of potentially carcinogenic lesions on mucous membranes

Fluorescence testing is increasingly being used to detect potentially malignant lesions on the surface of mucous membranes. According to the WHO, such
lesions include all abnormalities with a cancer risk such as oral leukoplakia, erythroplakia, lichen planus and submucous fibrosis. Tested tissues with a typical structure glow with an intensely green colour, while pathological structures appear to be dark spots with varying degrees of darkness. This is the so-called fluorescence visualisation loss (FVL), which may indicate abnormal tissue structure and increased cell division characteristic of cancer.

However, this is not a determining test, and no definitive diagnosis can be made on its basis, as inflammation, amalgam tattoos or haematomas, which do not pose a threat, also exhibit fluorescence loss. Therefore, any change lasting more than two weeks should be subject to histopathological verification (Fig. 11, Fig. 12).

To sum it up, fluorescence using a 405 nm laser is a safe, secure and very promising diagnostic method in dentistry. Considering the wide range of applications, this method may replace conventional diagnostics in a short future. For practitioners, it is a useful tool in everyday practice, allowing for ear-
ly detection of carious lesions as well as performing periodontal and oncological diagnostics, which gives the opportunity to take appropriate actions. However, further research and analyses are required in order to broaden the knowledge of its applicability.

References available from the authors.

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