In vivo comparison between measurement from two fluorescence-based devices of occlusal and smooth surface caries in primary and permanent teeth

Kazunori Takamori*, Yuko Tanaka, Makiko Iwasaki and Tetsuo Shirakawa

Department of Pediatric Dentistry, Nihon University School of Dentistry
1-8-13 Kanda-Surugadai, Chiyoda-ku, Tokyo 101-8310, JAPAN

Abstract
Fluorescence-based devices are adjunct tools for caries detection. Both DIAGNOdent 2095 (LF) and DIAGNOdent 2190 (LF pen) were developed for this application. The purpose of this in vivo study was to compare the relationship between the measurements obtained using the LF and LF pen devices in primary and permanent teeth. The same sample of occlusal and smooth surfaces caries were evaluated by one examiner using both LF and LF pen devices in children. For occlusal caries, measurements were made at 51 sites in primary teeth, and at 83 sites in permanent teeth. For smooth surface caries, measurements were made at 63 sites in primary teeth, and 163 sites in permanent teeth. The values obtained with the LF pen for occlusal caries in primary and permanent teeth (17.6 ± 2.14, 20.6 ± 1.40, respectively) were significantly higher than those obtained with the LF (9.7 ± 1.24, 11.3 ± 0.78). For caries on smooth surfaces, the values obtained with the LF pen for primary and permanent teeth (8.2 ± 1.22, 7.2 ± 0.45) were higher than those obtained with the LF (4.5 ± 0.57, 3.3 ± 0.23). For both occlusal and smooth surface caries, the values were significantly different between the two devices ($P<0.01$). The Spearman’s correlation coefficients comparing the LF and LF pen values for primary and permanent teeth were $R_s = 0.87$ and 0.86 for occlusal caries and 0.80 and 0.74 for smooth surface caries, respectively. Values from both devices showed high correlation coefficients, indicating similar principle of function. However, the actual values were significantly different, which indicated that the values obtained with the two devices did not agree. The LF pen should be used with caution in patients for whom the LF is already being used to manage caries.

Key words
Caries, DIAGNOdent, DIAGNOdent pen, Permanent teeth, Primary teeth

Introduction
Laser induced fluorescence has been used as a diagnostic methods for the early detection of enamel caries since its introduction in 1982. This sensitive method enables the detection of the early stages of caries on smooth surfaces and in fissures.

Use of fluorescence-based devices is established as adjuncts tools for early caries detection. In 1999, a laser fluorescence device (LF, DIAGNOdent 2095, KaVo, Biberach, Germany; Fig. 1A) with a pulsed near-infrared diode laser (wavelength 655 nm) was developed for the diagnosis of dental caries. With this device, pulsed laser irradiation of a carious lesion causes the emission of reflected fluorescent light at 700–800 nm. The reliability of the device was reported to be similar to that of conventional diagnostic methods used to detect caries in permanent and primary teeth. The apparatus uses two types of tip, type A reveals caries in fissure and type B detects caries on smooth surfaces (Fig. 1B, 50)
More recently a DIAGNOdent pen (DIAGNOdent 2190; LF pen; Fig. 1D) has been developed. This is a handheld device that again uses two types of tips, one to detect approximal caries, and the other to detect caries in occlusal and smooth surfaces (Fig. 1E, F).

With respect to performance, the LF pen is similar to the LF and the other diagnostic systems used currently to detect occlusal\textsuperscript{12–14} and approximal caries\textsuperscript{15} in permanent teeth. The devices also perform similarly with respect to the detection of occlusal\textsuperscript{16} and approximal caries\textsuperscript{16,17} in primary teeth. However, some reports have indicated that values obtained with the LF pen are significantly higher than those obtained with the LF\textsuperscript{14,16,18}. The relationship between the values obtained with the LF and the LF pen remains unclear. This relationship is important, because these devices are used not only to detect caries, but also in caries management. If the values given by the two devices are both different and independent, there is a possibility of misdiagnosis and confusion in the management of caries.

The aim of this \textit{in vivo} study was to compare the relationship between the LF and LF pen values obtained by assessing the same sites of occlusal and smooth surface caries in primary and permanent teeth.

**Materials and Methods**

All the experiments reported here were approved by the Institutional Ethics Committee Board at Nihon University School of Dentistry (2010-4).

Informed consent was obtained from all patients or guardian who participated in the study after a full explanation had been provided of the nature of the procedure, possible discomforts, and risks. The age range of the patient was 4 to 13 years (mean ± SD: 9.3 ± 2.72), and 10 male and 20 female were examined.

The fluorescence-based devices used were the LF (DIAGNOdent 2095, KaVo, Biberach, Germany) and the LF pen (DIAGNOdent 2190, KaVo, Biberach, Germany).

The measurements were taken by a single training examiner. The LF devices were calibrated for standard ceramic. The zero point for individual patients was obtained by adjustment from a healthy central incisor. Measurements were obtained from dry teeth after cleaning with a prophylaxis brush using water and dental floss, in accordance with the manufacturer’s instructions.

The measurements sites were in done in teeth with enamel and dentine caries selected by visual inspection. Three measurements were made for each...
Occlusal caries were evaluated using the type A tip of the LF device and the fissure probe of the LF pen. For smooth surface caries, the type B tip of the LF device and the same fissure probe of the LF pen were used. For occlusal caries, measurements were made at 51 and 83 sites in 40 primary and 72 permanent teeth, respectively. For smooth surface caries, measurements were made at 63 and 163 sites in 27 primary and 89 permanent teeth, respectively.

**Statistical analysis**

A paired $t$-test was performed to analyze differences between the LF and LF pen values. Spearman’s correlation coefficient was used to analyze the relationship between these values.

<table>
<thead>
<tr>
<th></th>
<th>LF</th>
<th>LF pen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fissure caries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary teeth</td>
<td>9.7 ± 1.24</td>
<td>17.6 ± 2.14*</td>
</tr>
<tr>
<td>Permanent teeth</td>
<td>11.3 ± 0.78</td>
<td>20.6 ± 1.40*</td>
</tr>
<tr>
<td>Smooth surface caries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary teeth</td>
<td>4.5 ± 0.57</td>
<td>8.2 ± 1.22*</td>
</tr>
<tr>
<td>Permanent teeth</td>
<td>3.3 ± 0.23</td>
<td>7.2 ± 0.45*</td>
</tr>
</tbody>
</table>

*: Statistically significant difference between the LF and LF pen values (paired $t$-test, $P<0.01$)

**Results**

The values obtained with the LF pen for occlusal caries in primary and permanent teeth ($17.6 ± 2.14$ and $20.6 ± 1.40$, respectively) were significantly higher than those obtained with the LF ($9.7 ± 1.24$ and $11.3 ± 0.78$, respectively; $P<0.01$). For smooth surface caries the values obtained with the LF pen for primary and permanent teeth ($8.2 ± 1.22$ and $7.2 ± 0.45$, respectively) were significantly higher than the values obtained with the LF ($4.5 ± 0.57$ and $3.3 ± 0.23$, respectively; $P<0.01$; Table 1).

The Spearman’s correlation coefficients were $R_s = 0.87$ and 0.86 for occlusal caries in primary and permanent teeth, respectively (Fig. 2A and B). For smooth surface caries, the correlation coefficients were $R_s = 0.80$ and 0.74 in primary and permanent teeth, respectively (Fig. 3A and B). The linear equations for the values obtained with the two
Comparison between two fluorescence-based devices value

Devices for occlusal caries were \( y = 1.56x + 2.33 \) and \( y = 1.56x + 3.05 \) for primary and permanent teeth, respectively (Fig. 2A and B). For caries on smooth surfaces, the equations were \( y = 1.97x - 0.58 \) and \( y = 1.93x + 1.57 \), respectively (Fig. 3A and B).

Discussion

The newly developed LF pen has the advantage of being able to detect approximal caries, which LF is unable to detect. The clinical gold standard for the diagnosis of approximal caries has been radiography combined with visual inspection. However, in the pediatric dentistry, there reluctance to use radiographic diagnosis, and its use should be discouraged, because of the hazards associated with ionizing radiation.

The LF pen could be used to replace bitewing radiographs, although these are known to have high intra-examiner reproducibility. Thus the LF pen could be a more useful device than the LF not only in caries the detection but also in the management of caries. These advantages suggest that the LF pen is superior to the LF.

However we observed significant differences between the LF and LF pen values obtained for occlusal and smooth surfaces caries. The mean value obtained with the LF pen was approximately twice that the value obtained with the LF in both cases. Similar results have been reported previously\(^{14,16,18}\). The reasons for the difference between the two devices is unclear, and no relevant information is available from the manufacturer. The two LF devices use the same wavelength and laser power. We have two suspects, one is the difference in tip material might modify the sensitivity of the detector. Another was LF pen tip the excitation and fluorescence follows the same optical path of propagation in opposite directions, different of the LF, which had independent optical path for excitation and fluorescence.

The correlation coefficients for the values from the two LF devices were high. For occlusal caries, the coefficients for primary and permanent teeth were similar. For smooth surface caries, the coefficient for permanent teeth was slightly lower than that for primary teeth, but correlation was adequate. These results suggest that the LF pen is as reliable in the detection of caries as the LF.

The above results are consistent with a similar gradient for the linear equation relating the LF pen and LF values for caries in occlusal \( (y = 1.56x) \) and on smooth surfaces \( (y = 1.93x) \). Thus, it would be easy to convert between the values obtained with the two LF devices. The results suggest that the LF pen has similar sensitivity when compared with the LF. The manufacturer’s instructions for the two devices show different cut-off limits for caries penetration, but the difference between the within limits of two times of value.

In conclusion, significant differences were found between the values obtained with the two LFs devices. Although individual values for the LF pen and LF did not match closely, high correlation coefficients were obtained when the two LF devices were compared.

Fig. 3 Relationship between values obtained with the LF and LF pen values for smooth surface caries in primary (A) and permanent (B) teeth.
We recommended that the LF and LF pen should be used with care in the clinic, and that only one device should be used on an individual patient.

Acknowledgments

This study was supported partially by the Sato Fund, Nihon University School of Dentistry.

References


