Reentry of endodontic access cavities: composite residue and loss of tooth substance

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Abstract

The purpose of this study was to investigate the ability of dentists to remove composite fillings from endodontic access cavities using illumination from a conventional light source (CLS) versus the fluorescence-aided identification technique (FIT) in terms of completeness, selectivity and treatment duration. Therefore, two independent operators removed composite resin from six sets of root-filled incisors in a maxillary model under simulated clinical conditions using the CLS or FIT method (twelve teeth per operator and technique). The duration of treatment was recorded and before-after micro-CT scans were superimposed for volumetric assessment of treatment completeness and selectivity. Statistical significance was determined by t-testing and two-way ANOVA for operator comparison.

Overall, there was no significant difference between FIT and CLS in terms of volume, height and area of composite residues \( (p=0.98 / p=0.75 / p=0.64) \) and regarding hard tissue loss in terms of volume, depth and area \( (p=0.93 / p=0.70 / p=0.14) \).

However, there was a significant difference between the two groups regarding treatment time \( (FIT=428s, CLS=523s; p=0.023) \).

Significant differences between operators regardless of method were found for volume, height and area of composite residues \( (p<0.05) \) and also for defect area \( (p=0.01) \) and time \( (p<0.001) \). Significant differences between operators including the method was only found for height of composites \( (p=0.037) \).

It can be concluded, that composite remnants and tooth structure losses may occur after reentry of root-filled teeth regardless of the illumination method (conventional vs. fluorescence-aided) and operator, but preparation was less time-consuming with FIT.
Introduction

The aim of root canal treatment is to maintain asepsis or to disinfect the root canal system (EUROPEAN SOCIETY OF ENDOdontOLOGY 2006). Root canal treatment is indicated for irreversible pulpal inflammation or necrosis, which may manifest with or without clinical symptoms. The root canal system of teeth with periapical pathosis is colonized by bacteria (Kakehashi et al. 1965) and must therefore be cleaned thoroughly (Bystrom et al. 1987). The first operative step of root canal treatment is the preparation of an adequate access cavity, followed by chemomechanical preparation of the root canals (Mannan et al. 2001; Patel et al. 2007; Johnson 2009). After root filling, the access cavity is usually restored with a composite filling, especially in anterior teeth.

If primary root canal treatment proves to be unsuccessful during follow-up, retreatment may be needed. Indications for root canal retreatment include a) inadequate root canal filling with radiological signs and/or symptoms of (newly) developing or non-healing apical periodontitis and b) inadequate root canal filling with discoloration requiring bleaching (EUROPEAN SOCIETY OF ENDOdontOLOGY 2006).

Internal bleaching is indicated in cases of internal discoloration of the tooth hard tissue. This phenomenon can be caused by blood degradation, antibiotic dressings, mineral trioxide aggregate, sealer, gutta-percha, temporary filling material, calcium hydroxide and zinc oxide eugenol cement (Van der Burgt et al. 1985; Van der Burgt et al. 1986a, b, c; Kim et al. 2000; Lenherr et al. 2012; Felman & Parashos 2013; Krastl et al. 2013; Forghani et al. 2016; Lee et al. 2016). Discoloration becomes apparent approximately two years after endodontic treatment (Lenherr et
AL. 2012, DETTWILER ET AL. 2016). In such cases, reentry of the access cavity is necessary.

For both endodontic retreatment and intracoronal bleaching, access to the root canal system is achieved by removing the existing coronal restoration, which is often a tooth-colored composite filling, especially in anterior teeth. During this procedure, care must be taken to ensure that tooth substance is not removed unnecessarily and that no composite residue is left behind. The former problem leads to a loss of tooth stability (REEH ET AL. 1989, LANG ET AL. 2006). The latter diminishes the quality and durability of the subsequent adhesive restoration (ATTIN ET AL. 2003) and makes bleaching ineffective because residual composite prevents the diffusion of bleaching agents.

Nowadays, light-curing composites are widely used aesthetic restorative materials that patients prefer over amalgam fillings. Composites are available in a variety of shades and translucencies that can be used to produce perfectly adapted restorations. This, however, makes the correct identification of composite restorations more complicated, time-consuming and unreliable. Despite good illumination and drying of the teeth during the examination, composite materials are often overlooked due to their high-quality aesthetics (TANI ET AL. 2003; UO ET AL. 2005; BUSH ET AL. 2010; MELLER ET AL. 2012, 2017). Moreover, false-positive identification of composite may occur, resulting in excessive or unnecessary removal of hard tooth substance during restorative procedures (UO ET AL. 2005, BUSH ET AL. 2010, DETTWILER ET AL. 2020).
The so-called “fluorescence-aided identification technique” (FIT) is an effective diagnostic tool in such indications (MELLER ET AL. 2017). As the majority of commercially available modern composites fluoresce more strongly than the natural tooth substance, fluorescent light allows the dentist to easily differentiate restorative materials from tooth substance (MELLER & KLEIN 2012, 2015). FIT is thus a reliable, noninvasive, and time-saving diagnostic procedure (MELLER ET AL. 2017). Meller and Klein observed that composite representation is best during excitation at a wavelength of (400 ± 5) nm (MELLER & KLEIN 2015). The FIT method shows significantly higher accuracy than the conventional method of detecting composite fillings (sensitivity) and intact teeth (specificity) (MELLER & KLEIN 2015). However, the optical fluorescence intensity of the composites appears to decrease with the age of the material (LEE ET AL. 2006 A,B; TAKAHASHI ET AL. 2008). There is also evidence showing that the fluorescence-inducing technique facilitates selective composite removal from posterior teeth (KLEIN ET AL. 2019; DETTWILER ET AL. 2020) and in trauma splint removal (DETTWILER ET AL. 2018) and orthodontic bracket debonding (RIBEIRO ET AL. 2017; STADLER ET AL. 2019).

To the best of our knowledge, there are no studies clarifying the effect of FIT on composite removal from endodontic access cavities. Therefore, the aim of the present study was to investigate the quality of composite restoration removal from endodontic access cavities with the aid of a conventional light source (CLS) compared with the fluorescence-aided identification technique (FIT).
Material and methods

Ethical approval

Ethical approval was obtained from the local research ethics committee (EKNZ UBE-15/111).

Model preparation

Twelve maxillary models were fabricated by a research assistant using irreversibly anonymized, human anterior teeth selected from a pool. Thoroughly cleaned and matching sound central and lateral incisors (FDI 12-22) were mounted in their normal anatomic positions. A sample model is shown in Figure 1. Exclusion criteria were incomplete root development, restorations, caries, fractures and cracks. To simulate clinical conditions, pink wax was used to mimic the gingiva. Models were always stored in water to prevent exsiccation. The study workflow is summarized in Figure 2.

Initial root canal treatment

Digital periapical radiographs with orthoradial projections were taken with an intraoral Minray X-ray system (Soredex, Tuusula, Finland) at an acceleration voltage of 60 kV and an exposure time of 0.16 s to determine the location, extent and length of the root canals. Conventional access cavities were prepared using a diamond-coated bur (307N, Intensiv SA, Montagnola, Switzerland). Root canal preparation was carried out to the full working length using reciprocating files (Reciproc 40, VDW GmbH, Munich, Germany). Root canal filling was performed with GuttaFlow Bioseal (Coltène / Whaledent GmbH & Co. KG, Langenau, Germany) and a central master point. The root fillings were reduced to two millimeters below the cemento-enamel junction, and
access cavities were cleaned with alcohol pellets. Finally, a control radiograph was obtained.

**Micro-CT imaging**

Micro-CT imaging was performed with the Skyscan 1275 X-ray microtomograph (Bruker microCT, Kontich, Belgium) using an acceleration voltage of 90 kV and a beam current of 111 µA. In order to increase the mean photon energy of the X-ray beam, a brass filter, provided by the supplier of the micro-CT-system, was placed between the X-ray source and the object. The angle of rotation step was set to 0.25 degrees, resulting in 1’440 projections equiangularly distributed over 360 degrees. At each rotation position, three radiographs were acquired with an exposure time of 0.53 s, yielding a total scan time of 42 minutes. A pixel length of 25 µm was used to fit the models into the field of view (FOV). After reconstruction using the manufacturer’s software, the files were exported to DICOM using VG Studio Max 2.2 (Volume Graphics, Heidelberg, Germany). One pre- and one postoperative micro-CT scan was performed for each model.

**Filling of access cavities**

After tooth color was digitally determined using the VITA Easyshade system (VITA Zahnfabrik, Bad Säckingen, Germany), the access cavities were restored with the matching dentin and enamel shades of Empress Direct composite (Ivoclar Vivadent, Schaan, Liechtenstein) as follows:

Enamel and dentin were etched for 30 s and 10 s, respectively, with Ultra-Etch phosphoric acid (Ultradent, South Jordan, UT, USA). Bonding was performed with Adhese Universal VivaPen (Ivoclar Vivodent AG, Schaan, Liechtenstein) according to
manufacturer’s recommendations. Composite fillings were layered (in 2-mm increments) using dentin shades and a final layer (0.5 mm) of an enamel shade, and were then light-cured by applying Bluephase polymerization light (Ivoclar Vivadent AG, Schaan, Liechtenstein) for a duration of 30 s each. The fillings were then polished with KENDA Hybrid light gray 0006 and pink 0106 (KENDA, Vaduz, Liechtenstein) and an Occlubrush (2503, Kerr Corp., Orange, CA, USA). A final control radiograph was taken, which also served as the diagnostic image for reentry.

**Reentry of access cavities**

The models were mounted in a vertically and laterally adjustable dental manikin (P-6, Frasaco GmbH, Tettnang, Germany). The final control radiographs from initial root canal treatment (RCT) served as the diagnostic images for reentry planning. The two operators participating in the study were general dentists with normal vision. Both had no color vision deficiency, as was determined beforehand with Ishihara plates. One had five years of professional experience (Operator A) and the other had just graduated from dental school (Operator B). Root canals were identified with FIT and CLS illumination alone, without the help of a magnifying glass or microscope. Both operators were tasked with completely removing the composite fillings from the access cavities of the model teeth by the FIT and CLS method, respectively, without extending the cavity. Each operator treated three models using a conventional light source (LEDview operating lamp, Sirona, Bensheim, Germany), and three models using a fluorescence-inducing headlamp (Karl Storz GmbH & Co. KG, Tuttlingen, Germany), for a total of six models each. The headlamp was set at a wavelength of 405 nm to produce a sharply defined beam of light, which was large enough to illuminate the entire oral cavity for a 40-cm working distance. Orange-tinted glasses were worn during treatment to enhance the contrast of the fluorescence-inducing
blue-violet light. The time required to complete the task was recorded for both methods. The endpoint was defined by the operator, who determined when the treatment was completed. Finally, a postoperative micro-CT was acquired with the same settings as described above.

**Geometrical measurements**

The reconstructed volumes were imported into VG Studio Max 2.2 (Volume Graphics, Heidelberg, Germany), and were then cropped into volumes of the individual teeth. The same software was used to superimpose pre- and postoperative data sets after a rigid registration using a cross-correlation algorithm (ANDRONACHE ET AL. 2008, MÜLLER ET AL. 2012; BUSCEMA ET AL. 2019). Evaluation of the teeth for the presence of composite residues and/or hard tooth substance defects was then possible (Figure 3). Six parameters were measured per tooth: maximum height of composite remnants, composite volume, composite area facing tooth substance, maximum defect depth, defect volume and defect area. The calculations of the parameters were carried out with an in-house script in Matlab R2017b (MathWorks, Natick, MA, USA).

**Statistical analysis**

All measurement data were imported into JMP software version 9 (SAS Institute Inc., Cary, NC, USA) and descriptively analyzed. Mean values, standard deviations (SD) and 95% confidence intervals (95% CI) were determined for each method. Statistical significance between methods was determined by the t-test. To assess the influence of the operator on the factors measured a two-way ANOVA was performed. The level of significance was set to \( p = 0.05 \).
Results

Composite residues

There were no significant differences between FIT and CLS illumination regarding composite residues. The mean volume of composite residue was 5.1 mm$^3$ (SD 5.7 mm$^3$; 95% CI: 2.7 – 7.5 mm$^3$) in the FIT group and 5.1 mm$^3$ (SD 4.5 mm$^3$; 95% CI: 0.9 – 3.2 mm$^3$; $p = 0.98$) in the CLS group. The mean height of composite residues was 0.63 mm (SD 0.45 mm; 95% CI: 0.44 – 0.82 mm) for FIT and 0.59 mm (SD 0.59 mm; 95% CI: 0.49 – 0.70 mm, $p = 0.75$) for CLS. The mean area of composite remnants facing tooth substance was 15.9 mm$^2$ (SD 14.8 mm$^2$; 95% CI: 9.7 – 22.2 mm$^2$) in the FIT group and 17.7 mm$^2$ (SD 12.2 mm$^2$; 95% CI: 12.6 – 22.9 mm$^2$, $p = 0.64$) in the CLS group.

Tooth substance defects

There was no significant difference in the loss of tooth substance between FIT and CLS illumination. The mean volume of hard tissue defects was 13.6 mm$^3$ (SD 7.9 mm$^3$; 95% CI: 10.1 – 16.8 mm$^3$) for FIT and 13.6 mm$^3$ (SD 8.9 mm$^3$; 95% CI: 9.9 – 17.4 mm$^3$; $p = 0.93$) for CLS. The mean depth was 0.82 mm (SD 0.27 mm; 95% CI: 0.71 – 0.94 mm) for FIT and 0.87 mm (SD 0.41 mm; 95% CI: 0.69 – 1.04 mm; $p = 0.70$) for CLS. The mean area of tooth substance defects was 56.4 mm$^2$ (SD 16.0 mm$^2$; 95% CI: 49.69 – 63.18 mm$^2$) in the FIT group and 48.3 mm$^2$ (SD 4.3 mm$^2$; 95% CI: 39.5 – 57.1 mm$^2$, $p = 0.14$) in the CLS group.

Treatment time

There was a significant difference between the two groups regarding treatment time. The mean time required for the removal procedure per trepanation was 428 s (SD
118 s; 95% CI: 378 – 478 s) in the FIT group and 523 s (SD 160 s; 95% CI: 456 – 590 s; \( p = 0.023 \)) in the CLS group.

The overall results are summarized in Table 1.

Table 1: Overall results per method (mean, standard deviation, 95% CI and p-value of t-test). Significant differences are marked with an asterisk (*).

<table>
<thead>
<tr>
<th></th>
<th>FIT</th>
<th></th>
<th>CLS</th>
<th></th>
<th>t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>SD</td>
<td>95% CI</td>
<td>mean</td>
<td>SD</td>
</tr>
<tr>
<td>Volume of composite [mm(^3)]</td>
<td>5.1</td>
<td>5.7</td>
<td>2.7 – 7.5</td>
<td>5.1</td>
<td>4.5</td>
</tr>
<tr>
<td>Height of composite [mm]</td>
<td>0.63</td>
<td>0.45</td>
<td>0.44 – 0.82</td>
<td>0.59</td>
<td>0.59</td>
</tr>
<tr>
<td>Area of composite [mm(^2)]</td>
<td>15.9</td>
<td>14.8</td>
<td>9.7 – 22.2</td>
<td>17.7</td>
<td>12.2</td>
</tr>
<tr>
<td>Volume of defect [mm(^3)]</td>
<td>13.6</td>
<td>7.9</td>
<td>10.1 – 16.8</td>
<td>13.6</td>
<td>8.9</td>
</tr>
<tr>
<td>Depth of defect [mm]</td>
<td>0.82</td>
<td>0.27</td>
<td>0.71 – 0.94</td>
<td>0.87</td>
<td>0.41</td>
</tr>
<tr>
<td>Area of defect [mm(^2)]</td>
<td>56.4</td>
<td>16.0</td>
<td>49.69 – 63.18</td>
<td>48.3</td>
<td>4.3</td>
</tr>
<tr>
<td>Time [s]</td>
<td>428</td>
<td>118</td>
<td>378 – 478</td>
<td>523</td>
<td>160</td>
</tr>
</tbody>
</table>

Results differentiated by operator

Results differentiated by operators for all measured variables are summarized in Table 2 (mean, standard deviation and 95% CI). Operator A had a professional experience of 5 years, operator B just graduated.
Table 2: Results differentiated by operators for all measured variables and both methods. Operator A had a professional experience of 5 years, operator B just graduated.

<table>
<thead>
<tr>
<th></th>
<th>Operator A</th>
<th></th>
<th>Operator B</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FIT</td>
<td>CLS</td>
<td>FIT</td>
<td>CLS</td>
</tr>
<tr>
<td></td>
<td>mean</td>
<td>SD</td>
<td>95% CI</td>
<td>mean</td>
</tr>
<tr>
<td>Height of composite [mm]</td>
<td>0.89</td>
<td>0.45</td>
<td>0.61 – 1.18</td>
<td>0.66</td>
</tr>
<tr>
<td>Depth of defect [mm]</td>
<td>0.73</td>
<td>0.24</td>
<td>0.57 – 0.89</td>
<td>0.81</td>
</tr>
<tr>
<td>Area of defect [mm²]</td>
<td>58.89</td>
<td>15.07</td>
<td>49.31 – 68.47</td>
<td>59.26</td>
</tr>
<tr>
<td>Time [s]</td>
<td>335</td>
<td>44</td>
<td>308 – 363</td>
<td>390</td>
</tr>
</tbody>
</table>

Table 3 shows results of the two-way analysis of variance (ANOVA). Significant differences between operators regardless of method were found for volume, height and area of composite residues (p<0.05) and also for defect area (p=0.01) and time.
(p<0.001). Significant differences between operators including the method was only found for height of composites (p=0.037).

Table 3: Results of two-way analysis of variance (ANOVA). Significant differences are marked with an asterisk (*).

<table>
<thead>
<tr>
<th></th>
<th>Two-way ANOVA</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>operator</td>
</tr>
<tr>
<td>Volume of composite</td>
<td>p=0.001*</td>
</tr>
<tr>
<td>Height of composite</td>
<td>p=0.001*</td>
</tr>
<tr>
<td>Area of composite</td>
<td>p=0.001*</td>
</tr>
<tr>
<td>Volume of defect</td>
<td>p=0.229</td>
</tr>
<tr>
<td>Depth of defect</td>
<td>p=0.131</td>
</tr>
<tr>
<td>Area of defect</td>
<td>p=0.010*</td>
</tr>
<tr>
<td>Time</td>
<td>p&gt;0.001*</td>
</tr>
</tbody>
</table>

**Discussion**

Selective removal of well-adapted composite restorations is challenging. This study aimed to investigate the efficacy of removal of composite restorations from endodontic access cavities with the aid of fluorescence (FIT) versus a conventional light source (CLS) in terms of completeness, selectivity, and duration. The results of this study show that composite residues remain and tooth substance is removed during reentry of endodontic access cavities with both illumination methods irrespective of the operator. Overall, the FIT method showed no significantly different selectivity compared with the CLS method. Also, the tooth substance defects were approximately the same size with both methods, but FIT resulted in quicker completion of the procedure.

Significant differences between operators regardless of method were found for volume, height and area of composite residues and also for defect area (p=0.01) and
time (p<0.001). Including the method, there was only a significant difference for the height of composites.

Direct composite restorations can match the natural tooth color very well, being almost undistinguishable from the adjacent tooth structure. The FIT method may help to visualize these restorations based on the fluorescence properties of composite and tooth substance (TANI ET AL. 2003; DETTWILER ET AL. 2020). The need for better methods for the detection of aesthetic restorations is growing (UO ET AL. 2005), as modern composite restorations pose an increasing diagnostic challenge due to their high aesthetics (TANI 2003, RIBEIRO ET AL. 2017; DETTWILER ET AL. 2018; STADLER ET AL. 2019). Meller and Klein tested the intensity of fluorescence of selected shades of a large number of commercially available composites and were able to show that the best detection of composite is achieved by stimulation with a light source at a wavelength of (400 ± 5) nm (MELLER & KLEIN 2012, 2015). Their results also showed that the maximum fluorescence intensities of the composites and their shades vary greatly.

In a further study, Meller and Klein showed that more than 80% of the observed composite shades have a higher maximum fluorescence excitation than enamel and dentin (MELLER & KLEIN 2015). They divided the composite resins into three groups according to maximum fluorescence intensity: The first group had weak fluorescence (not differentiable from the fluorescence of dentin and enamel), the second clearly detectable fluorescence (significantly higher excitation than that of dentin and enamel), and the third strong fluorescence. Empress Direct, which was used in the present study, belongs to the group of highly fluorescent composites.

Previous studies have shown that FIT not only facilitates the identification of tooth colored composite restorations (MELLER ET AL. 2017) but that it is also beneficial in
the removal of composite restorations from posterior teeth (DETTWILER ET AL. 2020) or
during orthodontic bracket and trauma splint debonding (RIBEIRO ET AL. 2017;
The results of this study do not correlate with these findings. A reason for this
discrepancy might be related to the difference in methodology. In cases of splint
removal and orthodontic bracket debonding, the fluorescence-inducing light is only
needed to illuminate the buccal/facial surface of the tooth, which is very easy to
assess. In this study, it was needed to illuminate narrow and deep endodontic
cavities. Apparently, that the intensity of the headlamp was insufficient to illuminate
composite remnants in these kinds of cavities. A built-in FIT-LED in the contra-angle
handpiece, which was used already in other studies (KLEIN ET AL. 2019; DETTWILER ET
AL. 2020), might be more efficient.
Although FIT does not enhance composite removal or prevent tooth substance
defects, it expedites the procedure.
From a clinical point of view, it would be desirable to avoid any unnecessary
substance defects, as this has a negative effect on tooth stability (REEH ET AL. 1989;
LANG ET AL. 2006).

Millar et al. proved that each time a restoration is removed, sound tooth tissue is also
removed and the cavity is enlarged. (MILLAR ET AL. 1992). So Forgie et al.
investigated the aid of magnification. They quantified the change in cavity size during
re-restoration of tooth-coloured occlusal composite restorations when unaided vision
and 2.6x magnification were used. There were significant increases in cavity size
using both techniques. The increase in size was less when magnification was used
but the difference was not statistically significant. Cavity size changes significantly
during re-restoration and the use of magnification may be of benefit for some
clinicians in reducing the size of the restoration. Subjectively, all the clinicians reported that magnification eased the task and were in favour of its use during routine work. (FORGIE ET AL., 2001). So a combination of FIT and magnification using magnifying glasses or a dental microscope might be beneficial.

Any large amounts of composite resin remaining in the cavity would render internal bleaching ineffective because they prevent bleaching agents from diffusing into the tooth structure. Internal bleaching ("walking bleach") is used to whiten discolored root-filled teeth (ATTIN ET AL. 2003). Teeth discolored due to trauma or necrosis can be successfully bleached in approximately 95% of cases. The access cavity should be designed in such a way that remnants of composite, root filling material and necrotic pulp tissue can be completely removed (ATTIN ET AL. 2003). Darkening after internal bleaching has been observed in several studies (FRIEDMAN 1997; MEIRELES ET AL. 2010), probably due to the diffusion of coloring substances and the penetration of bacteria due to a lack of marginal integrity of the restoration (ATTIN ET AL. 2003). The adhesion of composite to bleached tooth substance is temporarily reduced (TITLEY ET AL. 1988, 1992). It is assumed that peroxide or oxygen residues on the surfaces and pores of the teeth inhibit the polymerization of composite resin (TORNECK ET AL. 1990; DISHMAN ET AL. 1994). The structure of the composite also appears more irregular and more porous on bleached than unbleached enamel (TITLLEY ET AL. 1991; TÜRKÜN ET AL. 2004). This could explain why access cavities of bleached teeth filled with composite occasionally show marginal leakage (BARKHORDAR ET AL. 1997). The negative effects of hydrogen peroxide-containing bleaching agents on adhesion can be reduced by beveling the cavity moderately before etching (CVITKO ET AL. 1991). The same can be achieved by pretreating the pulp chamber with dehydrating agents such as alcohol or acetone-containing
adhesives (NIAT ET AL. 2012).

It is recommended to wait at least seven days after bleaching before placing the final restoration (TORNECK ET AL. 1991; ADIBFAR ET AL. 1992; TITLEY ET AL. 1993; BARKHORDAR ET AL. 1997; CAVALLI ET AL. 2001; ATTIN ET AL. 2004). This time period may be shortened by using an ascorbic acid rinse. Ascorbic acid and its salts are known antioxidants and can reduce many oxidative compounds, especially free radicals (BUETTNER ET AL. 1993; ROSE & BODE 1993).

Residual composite remaining in the access cavity will also affect the subsequent restoration. Several studies have shown that the bond strength of repaired fillings is lower than that of un repaired fillings (SÖDERHOLM & ROBERTS 1991; SHAHDAD & KENNEDY 1998; BORNSTEIN ET AL. 2005). Thus, the composite-to-composite adhesion is weaker than the adhesion of composite to enamel directly. Despite good repair options, one-piece restorations are more durable than repairs in the long term (PENNING 2001).

Clinically acceptable bond strength can be achieved through appropriate pretreatment methods (SHAHDAD ET AL. 1998), such as mechanical roughening and adhesive bonding (SHAHDAD ET AL 1998, RATHKE ET AL. 2009). It was found that the best adhesion could be achieved by pretreatment with alumina (PAPACCHINI ET AL. 2007) or silica (HANNIG ET AL. 2006). However, proper identification of composite resin is required for adequate pretreatment.

Measurements in this study were performed by means of micro-computed tomography. This technique provides a non-destructive and highly accurate tool for laboratory research (RHODES ET AL. 1999, PETERS ET AL. 2000). Especially in the field of endodontics, application of high resolution micro-CT has gained increasing
popularity in the last 25 years (AKSOY ET AL. 2020). Micro-CT technology is currently considered the most important and accurate research tool for the study of root canal system to understand the influence of its complex morphology on the different stages of endodontic treatment (VERSIANI & KELES 2000). It overcomes limitations of conventional methods allowing to evaluate anatomy not only qualitatively, but also to extract morphometric quantitative three-dimensional data without damaging the specimens (VERSIANI & KELES 2000). In this study, the superimposition of pre- and postoperative scans allowed the measurement of even very small composite residues or defects.

Other studies showed that the use of FIT, irrespective of operator`s experience (MELLER ET AL. 2017, DETTWILER ET AL. 2018, DETTWILER ET AL. 2020), facilitates satisfying results in identification and the removal of composite resin restorations. However, the present study does not confirm these results. This may be related to low number of operators (n=2) and the fact, that the field of endodontics might be more operator dependent than others. A recent study showed, that root canal treatment leads to high levels of stress and frustration among general dental practitioners. They also regarded root canal treatments as complex and with a sense of lack of control (DAHLSTRÖM ET AL. 2017).

**Conclusion**

It is difficult to completely and selectively remove well color-matched composite restorations from endodontic access cavities. The Fluorescence-aided Identification Technique (FIT) does not enhance selectivity but expedites the treatment.

**Acknowledgments**
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Zusammenfassung

Einleitung


Ziel der Studie war, die Trepanation von bereits wurzelkanalbehandelten Zähnen unter Fluoreszenz-induzierender Beleuchtung bezüglich Zeitbedarf, Verlust an Zahn­harts­sub­stanz und des Verbleibs von Kompositresten im Vergleich zu einer konventionellen Lichtquelle zu untersuchen.

Material und Methoden

Resultate

In Bezug auf die Kompositrückstände gab es insgesamt keine signifikanten Unterschiede zwischen FIT- und CLS-Beleuchtung. Das durchschnittliche Volumen des Kompositrückstands betrug 5,1 mm³ in der FIT-Gruppe und 5,1 mm³ in der CLS-Gruppe (p = 0,98). Die durchschnittliche Höhe des Komposites betrug 0,63 mm für FIT und 0,59 mm für CLS (p = 0,75). Die durchschnittliche Fläche der Kompositreste betrug 15,9 mm² in der FIT-Gruppe und 17,7 mm² in der CLS-Gruppe (p = 0,64).

In Bezug auf den Verlust der Zahnhartsubstanz gab es insgesamt keinen signifikanten Unterschied zwischen FIT- und CLS-Beleuchtung. Das mittlere Volumen an Hartgewebsdefekten betrug 13,6 mm³ für FIT und 13,6 mm³ für CLS (p = 0,93). Die mittlere Tiefe betrug 0,82 mm für FIT und 0,87 mm für CLS (p = 0,70). Die mittlere Fläche von Zahnsubstanzzdefekten betrug 56,4 mm² in der FIT-Gruppe und 48,3 mm² in der CLS-Gruppe (p = 0,14).

Hinsichtlich der Behandlungszeit gab es einen signifikanten Unterschied. Die erforderliche durchschnittliche Zeit pro Trepanation betrug 428 s in der FIT-Gruppe und 523 s in der CLS-Gruppe (p = 0,023).

Signifikante Unterschiede zwischen den beiden Behandlern gab es insgesamt bezüglich Volumen, Höhe und Fläche von Kompositrückständen (p<0.05), sowie für die Grösse der Defektfläche (p=0.01) und Zeit (p<0.001). Unter Berücksichtigung der Methode gab es nur einen signifikanten Unterschied zwischen den Behandlern bei der Höhe des Kompositrückstandes (p=0.037).

Diskussion

Farblich gut abgestimmte Kompositrestaurationen vollständig und selektiv aus endodontischen Zugangskavitäten bei einer Revision oder vor internem Bleaching zu

Résumé

Introduction

Lors de la trépanation d'une dent ayant subi un traitement de canal radiculaire, il est essentiel de préserver au mieux la substance dentaire dure et de retirer le composite aussi complètement que possible.

Les conséquences possibles sont la perte de stabilité de la dent, la qualité diminuée de la restauration adhésive ultérieure et l'échec en cas de blanchiment. Lorsque la teinte du composite est bien assortie à la dent, il est difficile d'enlever rapidement et sélectivement ce composite. La « Technique d'Identification assistée par Fluorescence » (« Fluorescence-aided Identification Technique », FIT) pourrait, le cas échéant, aider à différencier optiquement le matériau d'obturation de la substance dentaire dure.

Le but de cette étude était d'investiguer – en termes de temps de travail, de perte de structure dentaire dure et de présence résiduelle de composite – la trépanation de dents ayant déjà subi un traitement de canal radiculaire en utilisant un éclairage inducteur de fluorescence, comparativement à la même procédure utilisant une source de lumière conventionnelle.

Matériel et méthodes
Six modèles identiques de maxillaires supérieurs ont été fabriqués, chacun comportant 4 dents extraites (incisives centrales et latérales). Les dents ont subi un traitement canalaire et une restauration coronale avec obturation en composite de couleur assortie. Dans des conditions cliniques simulées, 2 médecins-dentistes installés en pratique privée indépendante ont trépané le même nombre de dents sur les 6 modèles à l’aide d’une source lumineuse conventionnelle (CLS) ou en utilisant la méthode FIT (n=12 pour chaque praticien et pour chaque technique). Le temps nécessaire a été enregistré et les micro-CT pré- et postopératoires ont été superposés afin de calculer les changements volumétriques concernant l’intégralité et la sélectivité de l’élimination du composite. La significativité statistique a été déterminée à l’aide d’un test t et d’une analyse de variance à deux facteurs.

**Résultats**

En ce qui concerne les restes de composite, il n’y a pas eu de différence globale significative entre l’éclairage FIT et l’éclairage CLS. Le volume moyen du composite résiduel a été de 5,1 mm$^3$ dans le groupe FIT et de 5,1 mm$^3$ dans le groupe CLS ($p = 0,98$). La hauteur moyenne du composite était de 0,63 mm avec FIT et de 0,59 mm avec CLS ($p = 0,75$). La surface moyenne des restes de composite était de 15,9 mm$^2$ dans le groupe FIT et de 17,7 mm$^2$ dans le groupe CLS ($p = 0,64$). Il n’y a pas eu de différence globale significative entre l’éclairage FIT et CLS en ce qui concerne la perte de substance dentaire dure. Le volume moyen des défauts de tissu dentaire dur a été de 13,6 mm$^3$ avec FIT et de 13,6 mm$^3$ avec CLS ($p = 0,93$). La profondeur moyenne a été de 0,82 mm avec FIT et de 0,87 mm avec CLS ($p = 0,70$). La surface moyenne des défauts de substance dentaire était de 56,4 mm$^2$ dans le groupe FIT et de 48,3 mm$^2$ dans le groupe CLS ($p = 0,14$).
Il y a eu une différence significative en termes de temps de traitement. Le temps moyen par trépanation était de 428 s dans le groupe FIT et de 523 s dans le groupe CLS (p=0,023).

Des différences significatives globales entre les 2 praticiens ont été mises en évidence en ce qui concerne le volume, la hauteur et la surface des restes de composite (p<0,05), ainsi que pour la surface du défaut de substance dentaire (p=0,01) et le temps de traitement (p<0,001). Compte tenu de la méthode utilisée, il y a eu seulement une différence significative entre les 2 praticiens en ce qui concerne la hauteur du composite résiduel (p=0,037).

**Discussion**

Lors d'une révision ou avant un blanchiment interne, il est très difficile d'éliminer complètement et sélectivement, dans les cavités d'accès endodontiques, les restaurations composites de teinte bien adaptée. Le but de cette étude était d'investiguer en termes d'intégralité, de sélectivité et de temps de traitement l'élimination du composite des cavités d'accès endodontiques, réalisée sous éclairage FIT et comparativement à une source lumineuse conventionnelle. La technique induisant une fluorescence n'augmente pas la sélectivité, mais accélère significativement le traitement.
References


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Figures


2. Study flow diagram. $^1$FIT = fluorescence-aided identification technique; $^2$CLS = conventional light source

3. Superimposed pre- and postoperative microCT scans used for volumetric analysis (randomly selected example). a: Preoperative layer. b: Three-dimensional overview. c: Postoperative layer showing residual resin in yellow. d: Postoperative layer showing tooth substance defect in blue. Scale in pixels (25 µm per pixel)