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

KEYWORDS
Resin composite restoration
Direct composite
Endodontics
Internal bleaching
Fluorescence-aided identification technique

SUMMARY

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 = 428 s, CLS = 523 s; $p = 0.023$). 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 ($p < 0.001$). A significant difference 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 chemo-mechanical 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, 1986a, 1986b, 1986c; 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. 2006a, 2006b; 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 during 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

Fig. 1 a: Maxillary model. b: Access cavities and root fillings. c: Restored access cavities with color-matched composite resin. d: Restored access cavities under fluorescent light (FIT).

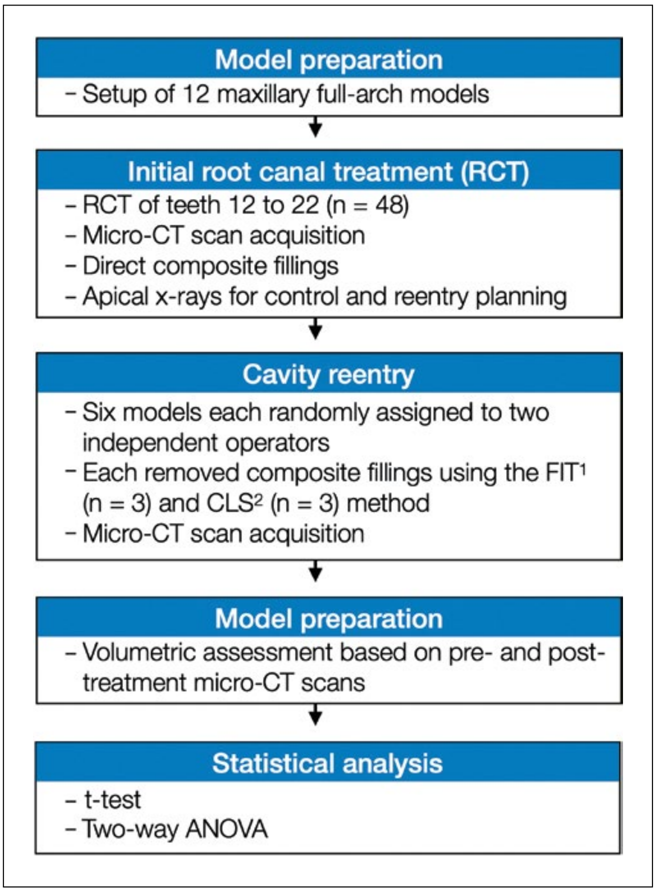

Fig. 2 Study flow diagram. [1]FIT = fluorescence-aided identification technique; [2]CLS = conventional light source.

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 the 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 the initial root canal treatment (RCT) served as the diagnostic images for the 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

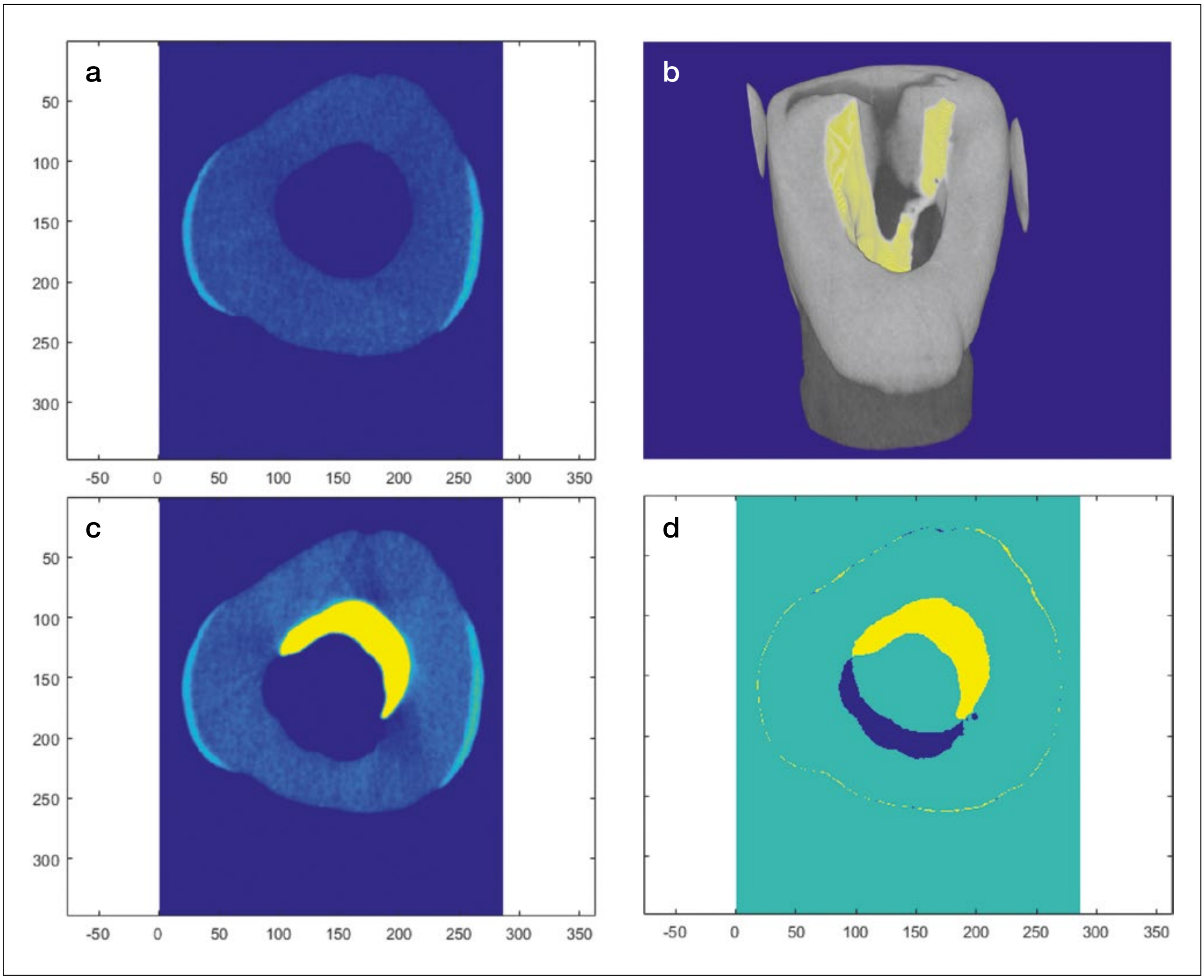

Fig. 3 Superimposed pre- and postoperative micro-CT scans used for volumetric analysis (randomly selected example). a: Preoperative layer. b: Three-dimensional overview. c: Postoperative layer showing residual resin in yellow. d: Postoperative layer showing tooth substance defect in blue. Scale in pixels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

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 (Fig. 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 of the differences 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 mm²; 95% CI: 12.6–22.9 mm², 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 mm³ (SD 7.9 mm³; 95% CI: 10.1–16.8 mm³) for FIT and 13.6 mm³ (SD 8.9 mm³; 95% CI: 9.9–17.4 mm³; 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 mm² (SD 16.0 mm²; 95% CI: 49.69–63.18 mm²) in the FIT group and 48.3 mm² (SD 4.3 mm²; 95% CI: 39.5–57.1 mm², 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 I.

Results differentiated by operator

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

Table III 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 ($p = 0.037$).

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; Dettwiler et al. 2018; Stadler et al. 2019).

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, 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-colored occlusal composite restorations when unaided vision and 2.6× 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 favor 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 pre-

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

	FIT			CLS			t-test
	mean	**SD**	**95% CI**	**mean**	**SD**	**95% CI**	**pfi**
Volume of composite [mm^3]	5.1	5.7	2.7–7.5	5.1	4.5	0.9–3.2	0.98
Height of composite [mm]	0.63	0.45	0.44–0.82	0.59	0.59	0.49–0.70	0.75
Area of composite [mm^2]	15.9	14.8	9.7–22.2	17.7	12.2	12.6–22.9	0.64
Volume of defect [mm^3]	13.6	7.9	10.1–16.8	13.6	8.9	9.9–17.4	0.93
Depth of defect [mm]	0.82	0.27	0.71–0.94	0.87	0.41	0.69–1.04	0.70
Area of defect [mm^2]	56.4	16.0	49.69–63.18	48.3	4.3	39.5–57.1	0.14
Time [s]	428	118	378–478	523	160	456–590	0.023*

Tab. II Results differentiated by operators for all measured variables and both methods. Operator A had a professional experience of five years, operator B just graduated.

	Operator A					
	FIT			**CLS**		
	mean	**SD**	**95% CI**	**mean**	**SD**	**95% CI**
Volume of composite [mm^3]	8.25	6.42	4.17–12.32	6.67	5.49	3.19–10.16
Height of composite [mm]	0.89	0.45	0.61–1.18	0.66	0.29	0.48–0.84
Area of composite [mm^2]	22.96	15.37	13.19–32.72	23.09	13.64	14.42–31.75
Volume of defect [mm^3]	10.37	6.33	6.35–14.39	13.74	10.42	7.11–20.36
Depth of defect [mm]	0.73	0.24	0.57–0.89	0.81	0.40	0.56–1.07
Area of defect [mm^2]	58.89	15.07	49.31–68.47	59.26	18.80	47.32–71.21
Time [s]	335	44	308–363	390	73	343–436
	Operator B					
	FIT			**CLS**		
	mean	**SD**	**95% CI**	**mean**	**SD**	**95% CI**
Volume of composite [mm^3]	1.97	2.28	0.52–3.42	3.47	2.66	1.78–5.17
Height of composite [mm]	0.37	0.28	0.20–0.55	0.54	0.19	0.41–0.66
Area of composite [mm^2]	8.88	10.61	2.14–15.62	12.39	8.07	7.26–17.52
Volume of defect [mm^3]	16.44	8.44	11.07–21.80	13.52	7.50	8.76–18.29
Depth of defect [mm]	0.93	0.27	0.75–1.10	0.93	0.44	0.65–1.20
Area of defect [mm^2]	53.98	17.13	43.10–64.86	37.34	17.36	26.31–48.37
Time [s]	520	93	461–579	656	97	594–718

Tab. III Results of two-way analysis of variance (ANOVA). Significant differences are marked with an asterisk (*).

	Two-way ANOVA		
	operator	**method**	**operator*method**
Volume of composite	p = 0.001*	p = 0.981	p = 0.249
Height of composite	p = 0.001*	p = 0.716	p = 0.037*
Area of composite	p = 0.001*	p = 0.609	p = 0.635
Volume of defect	p = 0.229	p = 0.929	p = 0.197
Depth of defect	p = 0.131	p = 0.693	p = 0.681
Area of defect	p = 0.010*	p = 0.108	p = 0.093
Time	p > 0.001*	p > 0.001*	p = 0.083

vent 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 (Titley 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 unrepaired 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 the 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 not only to evaluate anatomy 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, 2020), facilitates satisfying results in identification and removal of composite resin restorations. However, the present study does not confirm these results. This may be related to the 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 associated them 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.

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Zusammenfassung

Einleitung

Bei der Trepanation eines wurzelkanalbehandelten Zahns sollte die Zahnhartsubstanz geschont und das Komposit möglichst vollständig entfernt werden.

Mögliche Folgen sind Stabilitätsverlust des Zahnes, Qualitätsverlust der folgenden adhäsiven Restauration und Misserfolg im Falle eines Bleachings. Zahnfarbene Komposite erschweren eine schnelle und selektive Entfernung. Die «fluorescence-aided identification technique» (FIT) könnte unter Umständen helfen, Füllungen von der Zahnhartsubstanz optisch zu differenzieren.

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

Material und Methoden

Sechs Oberkiefermodelle mit je vier extrahierten Zähnen (mittlere und seitliche Schneidezähne) wurden hergestellt. Die Zähne wurden wurzelkanalbehandelt und koronal mit einer farblich passenden Kompositfüllung restauriert. Unter simulierten klinischen Bedingungen trepanierten zwei unabhängige Behandler die Zähne an jeweils sechs Modellen mit Unterstützung einer konventionellen Lichtquelle (CLS) oder der FIT-Methode (n = 12 pro Behandler und Technik). Die benötigte Zeit wurde aufgezeichnet und prä- und postoperative Mikro-CT-Scans wurden überlagert, um volumetrische Veränderungen bezüglich Vollständigkeit und Selektivität der Kompositentfernung zu berechnen. Die statistische Signifikanz wurde mittels t-Test und einer zweifaktoriellen Varianzanalyse bestimmt.

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 mm^3 in der FIT-Gruppe und 5,1 mm^3 in der CLS-Gruppe (p = 0,98). Die durchschnittliche Höhe des Komposits betrug 0,63 mm für FIT und 0,59 mm für CLS (p = 0,75). Die durchschnittliche Fläche der Kompositreste betrug 15,9 mm^2 in der FIT-Gruppe und 17,7 mm^2 in der CLS-Gruppe (p = 0,64).

Auch 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 mm^3 für FIT und 13,6 mm^3 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 Zahnsubstanzdefekten betrug 56,4 mm^2 in der FIT-Gruppe und 48,3 mm^2 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 der Kompositrückstände (p < 0,05) sowie bei der Grösse der Defektfläche (p = 0,01) und der Zeit (p < 0,001). Unter Berücksichtigung der Methode gab es nur bei der Höhe des Kompositrückstandes einen signifikanten Unterschied zwischen den Behandlern (p = 0,037).

Diskussion

Farblich gut abgestimmte Kompositrestaurationen bei einer Revision oder vor einem internen Bleaching vollständig und selektiv aus endodontischen Zugangskavitäten zu entfernen, ist sehr herausfordernd. Ziel dieser Studie war es, die Entfernung von Komposit aus endodontischen Zugangskavitäten mithilfe von FIT im Vergleich zu einer herkömmlichen Lichtquelle hinsichtlich Vollständigkeit, Selektivität und Dauer zu untersuchen. Die Fluoreszenz induzierende Technik erhöht die Selektivität nicht, beschleunigt jedoch die Behandlung signifikant.

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 quatre 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, deux médecins-dentistes installés en pratique privée indépendante ont trépané le même nombre de dents sur les six 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 deux 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 deux 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.

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