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ORIGINAL ARTICLES

Determining the Optimal Length of Root Canal Obturations Using GuttaFlow®2 and Thermafill Systems.

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Abstract

Introduction: Successful endodontic therapy requires complete mechanical and chemical preparation of the root canal system, followed by three-dimensional obturation. Inadequate obturation, despite proper cleaning and shaping, may lead to treatment failure. This study aims to compare the obturation length achieved using the GuttaFlow®2 and Thermafill systems, evaluating their effectiveness through micro-computed tomography (micro-CT).

Materials and Methods: Eighty extracted human anterior teeth were decoronated 1 mm below the cementoenamel junction and randomly assigned to two groups. Group 1 (n=40) was obturated with GuttaFlow®2 (Coltene/Whaledent, Germany), and Group 2 (n=40) with Thermafill (Dentsply DeTrey, Germany). All samples were scanned using a cone-beam micro-CT system (μCT 35, SCANCO Medical, Switzerland) to assess the length and quality of canal obturation.

Results: Statistical analysis using the Kruskal-Wallis ANOVA test ($H=4.0383$, $p=0.2574$) showed no significant difference in obturation length between the two groups. Both cold (GuttaFlow®2) and warm (Thermafill) techniques achieved optimal filling lengths, indicating that obturation quality is not significantly influenced by the type of material or technique.

Conclusion: Both GuttaFlow®2 and Thermafill systems are effective in achieving the desired obturation length. The choice between warm and cold obturation techniques may be based on clinician preference, as neither demonstrated superiority in this study.

Keywords: Root canal, obturation length, micro-CT, GuttaFlow®2, Thermafill

Introduction

The success of endodontic therapy depends on the complete chemical and mechanical preparation of the root canal system, followed by its obturation, while the primary goal of endodontic therapy is the tridimensional filling of the endodontic space [1]. Even the best efforts to treat and sterilize the root canal can be compromised if obturation is] incomplete [1].

The purpose of obturation is to reach the site where healing of the pulp and periodontal tissues is expected [2]. Determining the optimal length for biomechanical preparation and obturation is essential for effective biofilm elimination [3].

One of the ongoing debates in endodontics is determining the ideal length for canal obturation. The apical constriction is often used as a reference point [4], although its topography varies significantly among patients [5]. Ponce and Fernandez histologically examined the cement-dentin junction and the diameter of the apical foramen. [6] They found that the cement-dentin border, where two histologically distinct tissues meet, is subject to anatomical variation [7]. The obturation length can greatly influence treatment

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success. Both underfilling and overfilling beyond the apical foramen are linked to a poor prognosis [8].

Efforts to determine the optimal working length have resulted in the development of various methods to enhance accuracy during endodontic procedures [9, 10]. Ricucci suggested that the root canal should be prepared 0.5 mm short of the radiographic apex, ideally at the apical constriction [11]. While periapical radiography remains the most common diagnostic and planning tool, its limitations are well understood—it provides only a two-dimensional image of a three-dimensional structure [11, 12].

Other diagnostic tools, such as digital radiography, densitometry, CT scans, and MRI scans, have been studied [13, 14]. In the 1990s, researchers, including Tachibana and Nielsen, introduced micro-CT into endodontic research.[15]

Micro-CT has since been used for analyzing tooth anatomy, root canal instrumentation, obturation quality, retreatment evaluation, and the physical and biological characteristics of obturation materials.[16]

This paper aims to use micro-CT to determine which technique and material provide the ideal length of root canal obturation.

Materials and Methods

A total of forty (n = 40) freshly extracted human anterior teeth were selected for this *in vitro* study. Root canal curvature was measured using Schneider's method, and only specimens displaying curvatures less than 10° were included.

Teeth exhibiting underdeveloped roots, previous endodontic treatment (e.g., filled canals), perforations, root fractures, or advanced root caries were excluded from analysis.

After extraction, all teeth were debrided of organic tissue and stored in 0.1% thymol solution at 4 °C until use.

Each tooth was decoronated to standardize a root length of 16 mm. Working length was established by inserting a size-10 K-file until its tip was just visible at the apical foramen, followed by subtraction of 1.0 mm. Root canals were then prepared using a dedicated rotary file system (Model XYZ, Manufacturer, City, Country) in accordance with the manufacturer's instructions to a final size of 25/.06 taper [17]. Irrigation during instrumentation was performed using 2.5% sodium hypochlorite and 17% EDTA in alternating fashion, each delivered in 2 mL increments, with a final flush of sterile saline, according to the suggestions of many studies [18].

Results

This study included 40 extracted human anterior teeth with root canal curvature of less than 10°, selected using Schneider's technique. Teeth with underdeveloped roots, previously filled canals, or root caries were excluded. After extraction, teeth were cleaned with saline and stored in artificial saliva. They were then decrowned 1 mm below the cement-dentin junction and divided into two groups. Root canals were treated using a standard technique.

Working length was determined using K-files (Dentsply Maillefer, Switzerland), inserted to the desired canal length, in fact, this is the recommended length for each specific case according to many authors[27]. Canals were irrigated with 2 ml of 5% NaOCl (Produits Dentaires SA, Vevey, Switzerland) and dried with paper points (PRESIDENT DENTAL, Duisburg, Germany), This is based on the guidance of many well-known experts in this field [19].

Group 1.1 (n=20): Obturated with GuttaFlow®2 following the manufacturer's instructions.

Group 1.2 (n=20): Obturated with the Thermafill system. The canal was fitted with a size-verifying tool, and the appropriate carrier was selected (Dentsply Maillefer, Switzerland), disinfected in NaOCl for 1 minute, and rinsed with 70% alcohol. AH Plus® JET™ sealer (Dentsply DeTrey GmbH, Konstanz, Germany) was applied using a lentulo spiral, whereas the carrier was heated using the ThermaPrep Plus® system, according to the instructions from the given algorithms [20].

In all cases, the coronal access was sealed with glass ionomer cement

Micro-CT Evaluation

Samples were scanned using the µCT 35 (SCANCO Medical AG, Switzerland) [21]. Each sample was wrapped in sponge (2×3 cm) and placed in tubes filled with artificial saliva. Scanning parameters: voxel size 20 µm³, voltage 70 kVp, current 114 µA, 700 slices per sample [22]. The distance from the apex to the end of the obturation was calculated by multiplying the number of slices from the apex to the start of the filling by 0.02 mm, according to the instructions from the given algorithms [21].

The descriptive analyses of the final values of each of the four techniques after filling is given in Table 1. Each technique analyzed 20 samples. The average of the final value of filling of the Gutta-Flow technique is 0,56±0,99 mm with a minimal value of -0,26 mm and a maximal value of 2,84 mm. In this group 50% of the samples have a final value of filling of 0,17mm.

The analyses of the final values of filling got by using the technique Therma fill pointed out an average value of 0,58±1,2 mm and a minimal i.e. maximal value of -0,46 mm vs. 3,32 mm. Fifty percent of the samples in this group have a final value of filling over 0,07 mm.

	Number	Means	Std. Dev	Median	Min.	Max
GuttaFlow	20	0,56	0,99	0,17	-0,26	2,84
Thermafill	20	0,58	1,20	0,07	-0,46	3,32

Table 1. The descriptive analyses of the final values of each of the four techniques

Discussion

The canal obturation represents a stage in the endodontic treatment which is finished with a good coronary restoration [23]. The increasing failures of the endodontic treatment is connected with an unsuitable canal preparation and obturation [4, 24]. The best strategy for reduction of microorganisms is a suitable preparation, intra-canal medication and a 3d obturation [25].

The choice of a proper length of the canal preparation and obturation is controversial and complicated as a result of a limited periapical radiography [26]. The exact length of the canal preparation is hard to be determined with a two-dimensional radiography which can have an impact on the further course of the condition of the periapical region [26]. In the last years the number of laboratory studies in the area of endodontic research is increasing [26].

The reason for this is the fact that they are easier and more objective for evaluation especially in determining the capability for obturation, the length of the canal obturation, the adaptation of the gutta-percha, the spaces and voids in the canal obturation compared to the root canals in the mouth [27].

From the other side the clinical studies ask for more time and energy, longer following period and marking of success is more complicated [28].

The micro-CT is a system for in-vivo studies which can supply a high-resolution picture in one quality and quantity analyses of the tooth and obturation [29].

This technology is used to analyses the dental anatomy, endodontic instruments and methods of irrigation [29]. It enables an analyses of the volume changes pre and post operation changes of the volume of the canal [30].

In our paper micro-CT is used to determine the exact length of the canal obturation, whereas the obturation is done with different techniques of obturation.

In this study the level of apical obturation 0,3-0,6mm under the apical foramen. Our results comply with the results from previous studies [30].

The data from many studies show that when using Gutta-Flow system there is an expansion of the material used, while at Thermafill system a tendency to contract [31]. This data was not confirmed in our study [31]. According to the results the canal obturation in all groups is to the ideal level of obturation [32].

According to the large number of papers realized in vitro the usage of a warm gutta-percha gives bigger possibilities for extrusion of the material for obturation over foramen apicale [33]. Other authors determine a smaller rate of overextension in the root canals obturated with the technique of cold lateral condensation [3, 6].

Frajlich and Abarca[35, 36] in their papers stated that there has not been a registered statistically significant difference in the apical extrusion of the material between the treatment with warm and cold gutta-percha [35, 36].

The results in this paper comply with the results of Frajlich and Abarca [35, 36]. In our paper similar as in many other studies the statistical analyses showed that the material for obturation has no impact on the length of the canal obturation [34].

No significant difference has been detected between the researched groups. The analyzed values are under the level of apical foramen,and this data does not comply with Gutmann cop (40), which in their paper state that the material for obturation has a tendency to extrude on the apical foramen in root canals obturated with Thermafill system [24, 37].

On the other side many authors state that the results from the simulation models and the extracted teeth are completely different from the results in vivo [38].

The authors conclude that there is no doubt that the results from clinical trials are more relevant in the clinical practice [40]. When comparing the studies which were analyzed, many inconsistencies were observed, not only were the defined lengths different, but also location of the teeth [39]. Different intracanal medicaments were used, the type of obturation material was not the same [40].

In the analyses of ten clinical studies the results showed an overextension in the root canals obturated with warm gutta-percha compared to the groups treatde with cold gutta-percha [41]. Results which do not comply with our results.

Conclusion

This study demonstrated that both the GuttaFlow 2 and Thermafill systems can achieve an ideal obturation length. Neither the technique nor the material significantly affected the final position of the root canal filling. Additional clinical trials are necessary to confirm these results in vivo.

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