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In vitro experiment on the sealing ability by high-temperature thermoplasticized injectable technique and cold lateral condensation.

Kai Chen[1,#], Junyi Wu[1,#], Huawei Yang[1,*], Yuanzhi Xu[1], Raorao Wang[1], Guangwei Shang[1]

[1]Department of Stomatology, Tenth People's Hospital, Tongji University School of Medicine, Shanghai 200072, China
[#]Equal contributors

Abstract

The Objective of the present study is to compare the sealing ability of high-temperature thermoplasticized injectable technique and cold lateral condensation. 68 fresh in vitro teeth were divided into four groups: Group A (30 teeth), Group B (30 teeth), Positive Group (4 teeth), and Negative Group (4 teeth). In Group A, high-temperature thermoplasticized injectable technique was used, while in Group B, the cold lateral condensation technique was used. The root canal filling time, leakage phenomenon, sealing ability and compliance were compared in these groups. In Group A, the root canal filling time (6.48±0.45 min) and leaking length (1.02±0.14) were significantly lower than in Group B. The sealing capacity of 1.5mm, $>10^0$ and $<25^0$ root canal 1.5mm, and $\geq 25^0$ root canal 1.5mm and 3.5mm (0.9485±0.0218, 0.9504±0.0152, 0.9452±0.0147, and 0.9522±0.0142), and the compliance of 1.5mm and 3.5mm (0.9558±0.0164 and 0.9722±0.0142) were significantly higher in Group A than Group B ($P<0.05$). High-temperature thermoplasticized injectable technique can reduce the filling time, increase compliance, and has good sealing effects on root canal.

Keywords: Root canal filling; High-temperature thermoplasticized injectable technique; Cold lateral condensation technique; Sealing ability

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Introduction

Root canal therapy is the most effective and direct way for treatment of dental pulp and periapical disease, and the successful treatment needs to meet several preconditions: thorough removal of root canal, shaped root canal, good filling and sealing of root canal and root apex [1, 2]. Approximately 60% of root canal therapy failures are ascribed to incomplete root canal sealing, and 45% of root tip lesions are caused by imperfect root canal filling [3]. In consequence, finding an ideal root canal filling material and three-dimensional filling technique is very important. The commonly used cold lateral condensation technique in clinic at present is widely questioned due to poor sealing ability and compliance [4]. On that account, the paper adopts dye penetrate test and in-vitro study to compare the sealing effect of high-temperature thermoplasticized injectable technique and cold lateral condensation, thereby providing a reference for selection of appropriate root canal filling techniques in clinic.

Materials and Methods

Apparatus and Materials

Obtura Ⅱ high-temperature thermoplasticized filling machine was provided by Obtura Inc. in USA, MX-60N X-ray dental machine was from Japan, ultrasonic root canal therapeutic apparatus was from Satelec in France, stereomicroscope was from Germany Leica M300, lateral condensation machine was from Swiss DENTSPLY, zinc oxide was from Dental Materials Factory of Shanghai Medical instrument Co. Ltd, gutta percha point was from Dentsply International Inc., root canal sealer was from Dentsply International Inc. in USA (AH PLUS), and nickel-titanium devices (HERO SHAPER Brand) were from Micro-Mega in France.

Root canal preparation

All the extracted teeth were given root canal preparation by the same dentist, and carborundum was adopted to remove 1-2mm part of dental crown on the cementum junction. 15# K-file was inserted into the root canal with the working length of the distance from the root apex to dental crown mark point - 1mm. Root canal was prepared to 04 taper using NiTi motorized device in strict accordance with instructions. Ultrasound concussion was performed for 30 min by using medium-power of the ultrasonic treatment apparatus. 2ml 17% EDTA (ethylenediamine tetraacetic acid) + 2ml 2.5% sodium hypochlorite solution was used for irrigation of the root canal. The prepared root canal was irrigated by 2ml 2.5% sodium hypochlorite solution, and dried with paper points.

Grouping

68 teeth were all fresh and developed maxillary and mandibular teeth with single root canals which were removed due to periodontitis in our development of stomatology. Schneidr' sit method [5] was used to measure curvatures (11^0-38^0) of the root canal, among them, 34 teeth with curvature of 10^0 - 25^0 and 34 teeth with $\geq 25^0$. All the teeth were randomly divided into high-temperature thermoplasticized injectable technique group (group A, 30 teeth), cold lateral condensation (group B, 30 teeth), positive control group (4 teeth) and negative control group (4 teeth). The soft tissues and dental calculus on all the teeth root surfaces were removed. The obtained teeth were immersed in 5.25% sodium hypochlorite solution for 2 hours to disinfect, and stored in normal saline for use.

Filling method

Group A was adopted high-temperature thermoplasticized injectable technique for filling root canals to the working length through selecting 40#-50# thermoplasticized gutta percha point. A thin layer of sealing agent on the root canal walls was applied by using large needles with the corresponding model. The obtained root canals were compressed with a vertical compressor and then were placed into an incubator at 37ºC for 5d-7d. In Group B, cold lateral condensation technique was used for filling root canals, and the operation procedures were performed as follows: a 25# enlarge needle was adopted to apply a thin layer of root canal sealer on root canal walls, and a manual root canal spreader was used for continuous lateral condensing until the root canal was filled well. All the teeth with filled root canal were placed in an incubator at 37ºC for 5d-7d. The positive and negative group did not receive filling after root canal preparation. Glass ionomer cement was used to seal the root canal orifice.

Filling speed

A second chronograph was adopted to record the filling time of a single root canal, including preheating time of filling devices and completion time of the filling process. The average time for filling a single root canal in both groups was calculated.

Dye penetration test

Dye penetration test was conducted by referring the literatures by Carvalho-Sousa et al [6]. Nail polish was not applied in Negative Control Group, while it was applied in Positive Group for each tooth. Two layers of nail polishes were applied in both Group A and B on the root canal except for 2mm part from the root apex. All the teeth were immersed in 20% methylene blue solution, placed in a water bath at 37ºC for one week and taken out to irrigate the surface of the teeth for staining. Measurement was performed three times continuously for each specimen with a stereomicroscope (16x).

Measurement of sealing and compliance of the root canal cross-section

Fully consolidated teeth were selected from group A and B, and 0.5-1mm specimens were cut at 1.5 and 3.5mm cross sections from apical foramen with emery films. The two cross sections of each specimen were photographed under a JSM-36C scanning electron microscope (60x magnification), and MIAS-2000 image analysis system was adopted to accurately measure the total area of the root canal and filling area. Sealing and compliance indicators were calculated according to the formula in literatures by McFadden et al [7].

Sealing indicator of root canal=$(A_{tot}-V_f-V_a)/A_{tot}*100\%$
Compliance of root canal=$(A_{tot}-V_a)/A_{tot}*100\%$
A_{tot}= the total area of the root canal, V_F=the total area of the gap unconnected with the root canal wall, V_a=the total area of the gap connected with the root canal.

Statistical analysis

All the data were analyzed statistically by using SPSS13.0 software. Measurement data were expressed as mean ± SD ($\bar{x}$ ±s); *t* test was adopted. The difference with $P<0.05$ was considered to be statistically significant.

Results

Comparison of a single root canal filling time between the two techniques

The average time for filling a single root canal by using high-temperature thermoplasticized injectable technique and cold lateral condensation was 6.48±0.45 min and 8.24±0.65 min, respectively, and there were statistical differences between them (t=9.867, $P=0.000<0.01$).

Comparison of dye penetration length in different groups

The dye penetrated almost the whole root canal in the positive control group, and hardly in the negative control group, indicating that the dye penetration method was reliable. The penetration length in group A (1.02±0.14mm) was significantly less than that in group B ($P<0.05$). See Table 1.

Comparison of sealing ability of root canal with different cross sections

The sealing ability of root canal with the cross section at 1.5mm and 3.5mm showed a statistical difference by using cold lateral condensation technique; and the sealing abilities of root canal with the cross section both at 1.5mm and 3.5mm by using high-temperature thermoplasticized injectable technique were higher than those by using cold lateral condensation technique (the sealing ability at 1.5mm (0.9485±0.0218) was significantly higher) ($P<0.05$). See Table 2.

Comparison of sealing abilities of root canal with different curvatures

There were statistical differences in sealing abilities of the root canal with curvature of 10^0-25^0 and $\geq 25^0$ at 1.5 and 3.5mm cross sections by using cold lateral condensation technique ($P<0.05$). Compared with cold lateral condensation technique, the sealing abilities of all the root canals by using high-temperature thermoplasticized injectable technique were higher, and the abilities of root canal with curvature of 10^0-25^0 at 1.5mm (0.9504±0.0152) and of root canal with curvature of $\geq 25^0$ at 1.5mm and 3.5mm (0.9452±0.0147 and 0.9522±0.0142) were obviously higher ($P<0.05$). See Table 3.

Comparison of compliance of root canal with different cross sections

Differences in compliance of root canal with different cross sections at 1.5mm and 3.5mm were statistically significant by using the two techniques. Compliances at 1.5mm and 3.5mm by using high-temperature thermoplasticized injectable technique were obviously higher than that using cold lateral condensation technique ($P<0.05$). See Table 4.

Table 1. *Comparison of penetration length of dye by using high-temperature thermoplasticized injectable technique and* cold lateral condensation ($\bar{x}$ ±s)

Group	N	Range (mm)	Penetration length (mm)
Group A	30	0.78-1.12	1.02±0.14
Group B	30	1.22-1.48	1.33±0.18
Positive control group	4	5.56-8.67	7.84±1.12
Negative control group	4		0

Table 2. *Comparison of sealing abilities of root canal with different cross-sections filled by using high-temperature thermoplasticized injectable technique and cold lateral condensation technique ($\bar{x}$ ±s)*

Group	Part		T	P
	1.5mm	3.5mm		
Group A	0.9485±0.0218	0.9545±0.0221	1.102	0.645
Group B	0.9208±0.0206	0.9432±0.0212	2.312	0.034
T	2.654	2.345		
P	0.028	0.032		

Table 3. *Comparison of sealing abilities of root canal with different curvatures filled by using high-temperature* thermoplasticized injectable technique and cold lateral condensation technique ($\bar{x}$ ±s)

Group	10^0-25^0		$\geq 25^0$	
	1.5mm	3.5mm	1.5mm	3.5mm
Group A	0.9504±0.0152	0.9586±0.0201	0.9452±0.0147	0.9522±0.0142
Group B	0.9378±0.0142	0.9524±0.0205*	0.9123±0.0102	0.9362±0.0145*
T	2.478	1.112	3.456	2.345
P	0.042	0.435	0.038	0.041

*Note: compared with the cross section at 1.5 mm, *P<0.05.*

Table 4. *Comparison of compliance by using high-temperature thermoplasticized injectable technique and cold lateral* condensation technique ($\bar{x}$ ±s)

Group	Part		T	P
	1.5mm	3.5mm		
Group A	0.9558±0.0164	0.9722±0.0142	2.236	0.046
Group B	0.9378±0.0184	0.9596±0.0126	2.421	0.042
T	2.653	2.485		
P	0.036	0.038		

Discussion

Currently, high-temperature thermoplasticized injectable technique, cold lateral condensation and vertical condensation technique are clinical commonly used. The key indicators for evaluating the apical sealing effect of three-dimensional root canal filling are micro leakage, sealing ability, compliance, etc. The commonly used measures for assessment of sealing capability are dye penetration method, longitudinal opening method of root, electrochemical method, radioisotopic penetration, bacteria penetrating measurement, etc [8, 9]. For the dye penetration method, the gap between the root canal filling material and the root canal wall can be represented by the depth of staining in the root canal [10], which is simple to operate and high-sensitive.

For any techniques or materials, the efficacy is an important indicator for assessment of application performance. Our research shows that the filling time of a single root canal is significantly shorter by using the high-temperature thermoplasticized injectable technique than cold lateral condensation technique. The shorter filling time comes from the good liquidity and plasticity of hot gutta-percha which makes it reach the apical and irregular area of root canal rapidly. So far there're rare reports on this subject at home and abroad.

Some important indicators for assessing the three-dimensional filling of the root canal are apical sealing and micro leakage. Root canal re-infection can be effectively prevented through good apical sealing and leakage reduction [11]. Our study results showed that there was a significant difference in the performance of dye penetrating between the positive group and the negative group, which indicated that it was quite reliable to evaluate the experimental effect through dye penetration method. Meanwhile, the results showed that the penetrating depth of Obtra II was much lower than that in the cold lateral condensation technique group. Wang Miao, et al.[12] also proved this opinion through the comparison of cold lateral condensation technique, ultrasonic lateral condensation, and continuous wave hot gutta-percha vertical condensation. It is also related with the liquidity, plasticity, and homogeneity of hot gutta-percha, which makes it much easier to reach the root apex with smaller gap so that gutta percha point is more tightly connected with the root canal wall to effectively prevent leakage.

It's seldom found in public literatures about the research on high-temperature thermoplasticized injectable technique and cold lateral condensation technique in different curvatures and cross sections. Our study was the first to compare the two cross sections at 1.5mm and 3.5mm from the root apex. The results suggested that the sealing abilities between root canals with two cross sections by using cold lateral condensation were significantly different and were both weaker than those by using high-temperature thermoplasticized injectable technique. The further research on the root canals with different curvatures (10°-25° and ≥25°) at different cross sections (1.5mm and 3.5mm) showed the significant difference of sealing ability in the cold lateral condensation group, while the high-temperature thermoplasticized injectable technique groups displayed similar results, which were better than those in cold lateral condensation groups. It was basically identical with the experimental results of the cross-sectional area measurement by Wang XY, et al [13], which indicated good sealing capacity of root canal by using high-temperature thermoplasticized injectable technique.

The liquidity property of filling material and its effect on sealing ability of the root canal is often represented by compliance which was measured often by semi-quantitative methods previously [14]. The cross-sectional morphology adopted for measurement in the study was more accurate [15], and the results indicated that the high-temperature thermoplasticized injectable technique had better effects on the two cross sections of 1.5mm and 3.5mm, which supported the previously-mentioned conclusion that the sealing capacity with high-temperature thermoplasticized injectable technique was better than cold lateral condensation technique.

In summary, it is concluded that thermophsticized gutta-percha material can effectively improve the sealing ability and the compliance of the root canal with different cross sections and curvatures due to shorter filling time and penetration length of a single root canal. These may be caused by good fluidity, plasticity and homogeneity, what needs to be tested in clinical practice.

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[*]**Correspondence to:**

Huawei Yang
Department of Stomatology
Tenth People’s Hospital
Tongji University School of Medicine
Shanghai 200072
China