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Original Article

Efficacy of warm gutta-percha root canal filling in the treatment of dental pulpal and periapical diseases

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Abstract: Objective: To explore the efficacy of warm gutta-percha root canal filling in the treatment of dental pulpal and periapical diseases as well as to preliminarily discuss the mechanism of its effectivity. Methods: One hundred and twelve patients with pulpal and periapical diseases from January 2017 to February 2018 in Gansu Provincial Hospital were selected and randomly divided into two groups, the control group and the observation group. The control group was treated with lateral compaction filling, while the observation group with warm gutta-percha root canal filling. Measurements including clinical efficacy, the rate of excellent and good filling, pain intensity scoring, incidence of adverse reactions, gingival index (GI) and periodontal pocket depth (PPD) as well as sulcus bleeding index (SBI) were compared between the two groups. Also compared were the changes of the levels of IL-1 and TNF-α in the serum of both groups. Results: The rate of excellent and good filling in the observation group (94.7%) was significantly higher than that in the control group (63.6%) (P<0.001). The total effective rate of treatment in the observation group was significantly higher than that in the control group (P<0.001). The Visual Analogue Scale score of the observation group was significantly lower than that of the control group (P<0.001). The incidence of adverse reactions in the observation group was significantly lower than that in the control group (P=0.032). There was no significant difference in preoperative GI, SBI, and PPD between the two groups. Moreover, the measurements of both groups were significantly decreased after treatment (P<0.001), and the decreases in the observation group were significantly higher than those of the control group (P<0.001). The proper filling rate of both groups were significantly reduced after treatment (P<0.001), while the ratio of the observation group was significantly higher than that of the control group (P=0.004) and the reduction of the observation group was significantly higher than that of the control group (P<0.001). Besides, IL-1 and TNF-α in serum of both groups were significantly decreased after treatment, and the decreases in the observation group were significantly higher than those in the control group (P<0.001). Conclusion: The using of warm gutta-percha root canal filling in the treatment of dental pulpal and periapical diseases reduces the expression of postoperative inflammatory factors and at the same time significantly improves the clinical efficacy, which is worthy of promotion and application in clinical practice.

Keywords: Warm gutta-percha root canal filling, dental pulpal disease, periapical disease, IL-1, TNF-α

Introduction

Pulpal and periapical diseases are the most common dental diseases in clinical practice, which can lead to many relatively serious such damages to patients as destruction of alveolar bone or normal tissues of periodontal ligament caused by bacterial growth in the root canal. In this condition, patients' chewing the food will cause pain in teeth, and looseness of teeth on a much larger scale, which bring troubles to their eating [1-3]. Root canal treatment, which mainly includes lateral compaction filling and warm gutta-percha filling, is generally adopted in these diseases clinically, through which occurrence of infection of periapical tissue caused by these diseases can be reduced [4, 5]. Lateral compaction filling is widely used clinically because of its earlier appearance. Warm gutta-percha filling has been later put in use with the continuous development of root canal filling technology. In this technology, gutta-percha is used to fill the root canal after being heated to a flowing state, which can well fill all

the gaps of root canal and thus lead to a better filling [6-8].

In this study, the two fillings mentioned above were put into use to explore the efficacy of warm gutta-percha root canal filling in the treatment of dental pulpal and periapical diseases as well as its effect on IL-1 and TNF-α in serum of the patients, hoping to know about the value of warm gutta-percha root canal filling and provide a more scientific basis for clinical treatment.

Materials and methods

Patients

A total of 112 patients diagnosed as pulpal and periapical diseases in Gansu Provincial Hospital from January 2017 to February 2018 were selected and randomly divided into two groups, the control group (n=55) and the observation group (n=57). This study was approved by the Medical Ethics Committee of Gansu Provincial Hospital, and informed consents were obtained from all the patients or their families.

Inclusion criteria: Vital organs such as heart, liver and kidney in all the patients have not undergone severe damages; all the patients met the criteria for the diagnosis of dental pulpal and periapical diseases; no treatments were performed in root canals of all the patients previously; there were no calcifications in the root canals; the tooth in the patients were kept in good hygienic condition; and all the patients were relative healthy and could tolerate this surgery.

Exclusion criteria: Patient who suffered from mental illness and had a poor compliance was excluded; patient who suffered from other periodontal diseases was excluded; patients with tooth fractures induced by non-disease factors were excluded.

Methods

In this study, the control group was treated with lateral compaction filling, while the observation group with warm gutta-percha root canal filling [9].

Preoperative preparation: Conditions about the root canal, cusp and periodontal parts were evaluated through radiographic examination before all the surgeries; relevant parameters of the nickel-titanium rotary instrument ((China) Shanghai Yirui Dental Materials Co., Ltd.) were set according to the length of the root canal, and the instrument should ensure reach to the working length of about 2 mm when setting the parameters; the root canals were cleaned and disinfected using 1% sodium hypochlorite and 2% chlorhexidine before insertion, and the damages to the periapical tissues were minimized during root canal preparation.

The control group was treated with lateral compaction filling. Appropriate master gutta-percha cones ((China) Tianjin Zhongjin Pharmaceutical Co., Ltd.) were selected according to the determination of the working length of the root canal, after which the master gutta-percha cones dipped with small amount of sealer ((China) Shenzhen Hebron Trading Co., Ltd.) were inserted to the full working length and were filled by the lateral compaction. The fillings of accessory gutta-percha cones were undergone after the master gutta-percha cones, and were finished with the same lateral compaction.

The observation group was treated with warm gutta-percha root canal filling, that is, this group adopted vertical compaction using non-standard gutta-percha cones. The most appropriate master gutta-percha cone, plugger and heating tip were selected according to the working length of the root canal and the specific condition that master apical file was in. Trail of cone fitting was conducted before filling. The master cone lightly coated with sealer at its apical area was inserted to the full working length of the root canal. The heating tip was activated to a setting of 200°C, and the coronal excess of the gutta-percha cone was sheared off at the point of 4 mm away from the apex. After taking out the truncated part of the cone, a plugger was used in condensation. Then the upper working length was completed with the help of plugger. The clinical efficacy and adverse reactions of the two groups were observed and noted 2 months after their fillings.

Measurements

The rate of excellent and good root canal filling: In this evaluation, the one whose radiograph showed that the distance between the point of the filling material and the apex of the root was in the range of 0.5 mm to 2.0 mm, and that the

Table 1. Comparison of general characteristics between the two groups ($\bar{x}$ ± sd)

	The control group (n=55)	The observation group (n=57)	t/χ^2	P
Age range (years)	21-66	20-62		
Average age (years)	40.53 ± 4.98	39.23 ± 4.08	1.514	0.133
Sex (male/female)	25/30	25/32	0.029	0.865
Root canals	145	152		
Anterior teeth	33	36		
Premolars	23	23		
Molars	4	8		

three-dimensional compactness was good as well as that the filling material was tightly combined with the wall of the canal was considered as an excellent filling; the one whose radiograph showed the distance between the point of the filling material and the apex of the root was in the range of 0.5 mm to 2.0 mm, and that the density of the filling material is not uniform as well as that there are two or less micro gaps in about one third area of the filling material was considered as a good filling; the one whose radiograph showed that the density of the filling material is not uniform and that there is a clear gap between the filling material and the canal wall was considered as a fair filling; the one whose radiograph showed that the distance between the point of the filling material and the apex of the root was more than 2 mm was considered as a poor filling. The rate of excellent and good filling = (cases of excellent filling + cases of good filling)/total cases * 100% [10].

Clinical efficacy

As for the evaluation of clinical efficacy, the cases were evaluated and then divided into three scales. The one whose clinical symptoms disappeared after two months of treatment, and whose occlusal function returned to normal as well as whose radiograph showed no lesion in the apical area was considered as a cure case; the one whose clinical symptoms disappeared after two months of treatment, and whose occlusal function was improved as well as whose radiograph showed significant reduction of the lesion was considered as an effective case; the one whose clinical symptoms showed no disappearance or even got worse after treatment, and whose radiograph showed no changes in the lesion of the apical area was considered as an invalid case [11].

Pain assessment

Pain was scored using Visual Analogue Scale (VAS), in which 0 indicated no pain, and 10 indicated severe pain. The higher the score, the severer the pain was [12].

GI, SBI and PPD

Gingival index (GI) was scored on a 4-point scale: normal (0 point), mild (1 point), moderate (2 points) and severe (3 points). In the scoring, those who showed no abnormal conditions in the gingiva were scored with 0 point; those who got a mild gingival inflammation with mild color change, no bleeding when probing and slight edema were scored with 1 point; those who got moderate gingival inflammation with swelling and bleeding when probing were scored with 2 points; those who got severe gingival inflammations with oral ulcers and spontaneous bleedings were scored with 3 points.

Sulcus bleeding index (SBI) was scored on a 4-point scale: those who showed no gingival sulci were scored with 1 point; those ones who have normal appearances in the gingiva with bleeding when lightly probing were scored with 2 points; those ones whose gingivae were red with bleeding when lightly probing and no swelling were scored with 3 points; those ones whose gingivae were bleeding with ulcers were cored with 4 points.

Periodontal pocket depth (PPD) was measured with an ordinary periodontal probe. Measurements of each tooth were obtained at six sites including mesio-buccal, mid-buccal, disto-buccal, mesio-ligual, mid-lingual and disto-ligual sites.

Excess filling materials were remove out following the root canal filling, during which the root canal should be kept clean. And then the GI, SBI and PPD were obtained [13].

Detection of TNF-α and IL-1 in serum

Venous blood was taken from the patients in a fasting state, and then serum was collected by centrifugation. TNF-α (Thermo Fisher Scientific (China) Co., Ltd.) and IL-1 (Thermo Scientific

Table 2. Comparison of rate of excellent and good filling between two groups (n, %)

	Excellent	Good	Fair	Poor	The excellent and good rate
The observation group (n=57)	42 (73.7)	12 (21.0)	2 (3.5)	1 (1.8)	54 (94.7)
The control group (n=55)	24 (43.6)	11 (20.0)	14 (25.5)	6 (10.9)	35 (63.6)
χ^2					16.591
P					<0.001

Table 3. Comparison of clinical efficacy between two groups (n, %)

	Cure	Effective	Ineffective	Total rate of efficacy
The observation group (n=57)	45	11	1	56 (98.2)
The control group (n=55)	27	12	16	39 (70.9)
χ^2				16.247
P				<0.001

Table 4. Comparison of pain intensity scoring between two groups

	VAS score
The control group (n=55)	2.43 ± 0.34
The observation group (n=57)	1.82 ± 0.19
t	11.664
P	<0.001

Note: VAS, visual analogue scale.

(China) Co., Ltd.) were determined by enzyme-linked immunoassay [14]. Operation is strictly in accordance with the kit instructions.

Proper root canal filling and filling time

After the root canal filling, the one whose radiograph showed that the filling material was tightly combined with the root canal wall, and that the filling material reached to the cementum-dentin junction as well as that the distance between the filling material and the apex was exactly in the range of 0.5 mm to 2.0 mm was considered as a proper root canal filling. The filling time spanned from the very beginning of the filling to the completion of the surgical procedure.

Statistical analysis

Statistical analysis was performed using SPSS package for Windows, version 19.0. Measurement data in both groups were expressed as mean ± standard deviation ($\overline{x}$ ± sd), on which the t-test was performed. Enumeration data were expressed as percentages (ratios) using the χ^2 test and the Fisher exact probability test, in which P<0.05 is considered statistically significant.

Results

Comparison of general characteristics between the two groups

There was no significant difference in age and sex between the control group and the observation group (both P>0.05). In all treated teeth, there were 33 anterior teeth, 23 premolars and 4 molars in the control group, which contained 145 root canals; while there were 36 anterior teeth, 23 premolars and 8 molars in the observation group, which contained 152 root canals (**Table 1**).

Comparison of rate of excellent and good filling between two groups

In the observation group, 42 patients were evaluated as excellent ones and 12 patients as good ones, which made a total rate of excellent and good filling of 94.7%. While in the control group, 24 patients were evaluated as excellent ones and 11 patients were evaluated as good ones, which made the rate 63.6%. The rate of excellent and good filling in the observation group was significantly higher than that in the control group (P<0.001), which showed statistically significant difference (**Table 2**).

Comparison of clinical efficacy between two groups

In the observation group, 45 patients were cured and 11 were effective, which arrived at the total effective rate of 98.2%. While in the control group, 27 patients were cured and 12 were effective, which made a total effective rate of 70.9%. The total effective rate in the control group was significantly lower than that

Table 5. Comparison of incidence of adverse reactions (n, %)

	Swelling and pain in gingivae	Leakage of the filling materials	Loosening of gutta-percha cones	Total
The observation group (n=57)	1	0	0	1 (1.7)
The control group (n=55)	2	4	2	8 (14.5)
χ^2				4.587
P				0.032

Table 6. Comparison of GI of the two groups before and after treatment ($\bar{x}$ ± sd)

	Before treatment	After treatment	t	p
The observation group (n=57)	2.97 ± 0.34	1.33 ± 0.12	38.017	<0.001
The control group (n=55)	2.93 ± 0.37	1.85 ± 0.12	21.221	<0.001
t	0.596	22.926		
P	0.552	<0.001		

Note: GI, Gingival index.

Table 7. Comparison of SBI of the two groups before and after treatment ($\bar{x}$ ± sd)

	Before treatment	After treatment	t	p
The observation group (n=57)	3.27 ± 0.32	1.36 ± 0.12	40.591	<0.001
The control group (n=55)	3.16 ± 0.38	2.27 ± 0.28	41.249	<0.001
t	1.659	-22.214		
P	0.100	<0.001		

Note: SBI, Sulcus bleeding index.

Table 8. Comparison of PPD of the two groups before and after treatment ($\bar{x}$ ± sd)

	Before treatment	After treatment	t	p
The observation group (n=57)	6.23 ± 0.65	4.09 ± 0.43	20.777	<0.001
The control group (n=55)	6.29 ± 0.67	5.34 ± 0.55	7.845	<0.001
t	-0.481	-13.368		
P	<0.001	<0.001		

Note: PPD, periodontal pocket depth.

in the observation group (P<0.001), which was statistically significant (**Table 3**).

Comparison of pain intensity scoring between two groups

The VAS score in the control group was 2.43 ± 0.34, while that in the observation group was 1.82 ± 0.19. The scores in the observation group were significantly lower than those in the control group (t=11.664, P<0.001), which showed statistically significant difference (**Table 4**).

Comparison of incidence of adverse reactions

The incidence of adverse reactions in the observation group was 1.7%, which contained one patient with swelling and pain in the gingiva. While the incidence of adverse reactions in the control group was 14.5%, which contained 2 cases with gingival swelling and pain, 4 with microleakage of filling material and 2 with loose gutta-percha cone. The incidence of adverse reactions in the observation group was significantly lower than that in the control group (χ^2=4.587, P=0.032), (**Table 5**).

Comparison of GI, SBI and PPD of the two groups before and after treatment

There were no significant differences in the preoperative GI, SBI, and PPD between the two groups. The above three indicators of both groups were significantly decreased after treatment (P<0.001), and the decreased degree of the observation group was significantly higher than that of the control group (P<0.001), (**Tables 6**-**8**).

Comparison of the proper filling rate and the filling time between two groups

The filling time of the control group was 159.34 ± 12.32 min, and the filling time of the observation group was 68.23 ± 5.98 min. The filling

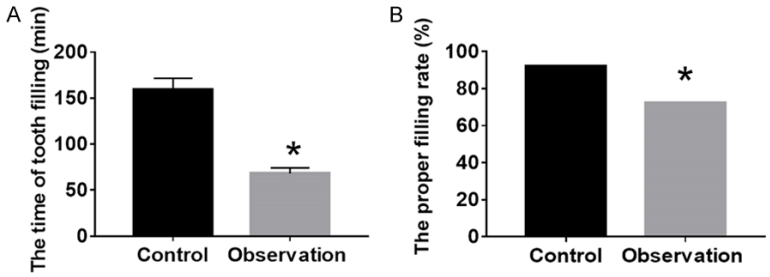

Figure 1. Comparison of the proper filling rate and the time of tooth filling between two groups. A: Comparison of the proper filling rate between two groups; B: Comparison of the time of tooth filling between two groups; comparison between the observation group and the control group (*P<0.05).

Table 9. Comparison of TNF-α of the two groups before and after treatment (ng/mL, $\bar{x}$ ± sd)

	Before treatment	After treatment	t	p
The observation group (n=57)	9.82 ± 0.97	3.21 ± 0.32	57.613	<0.001
The control group (n=55)	9.73 ± 0.96	5.69 ± 0.57	27.916	<0.001
t	0.493	-28.255		
P	0.623	<0.001		

Table 10. Comparison of IL-1 of the two groups before and after treatment (ng/mL, $\bar{x}$ ± sd)

	Before treatment	After treatment	t	p
The observation group (n=57)	14.27 ± 1.32	5.00 ± 0.54	56.596	<0.001
The control group (n=55)	14.31 ± 1.76	7.98 ± 0.75	19.959	<0.001
t	-0.136	-24.058		
P	0.892	<0.001		

time of the control group was significantly longer than that of the observation group (t=-49.506, P<0.001), which showed significant difference (**Figure 1A**). The proper filling rate of the control group was 72.7%, and the rate of the observation group was 93.0%. The proper filling rate of the observation group was significantly higher than that of the control group (χ^2=8.153, P=0.004), which showed significant difference (**Figure 1B**).

Comparison of TNF-α and IL-1 of the two groups

There was no significant difference in TNF-α and IL-1 levels between the two groups before treatment (P>0.05). While the above two indicators in both groups were significantly lower after treatment (P<0.001), and the decreased degree of observation group was significantly higher than that of the control group (P<0.001), (**Tables 9**, **10**).

Discussion

The dental pulpal and periapical diseases are of high incidence in oral diseases, which are mainly put the dental pulpal and periodontal tissues into a pathological state, and causes infection and damage to alveolar bones and gingivae. If not treated in time, it may cause occlusal pain and difficulty in chewing, which further leads to inability to feed and malnourish symptoms [15]. The clinical treatment of the disease is done mainly through the removal of the lesions in the root canal and the root canal filling, which reduces the infection of pathogenic microorganisms to the root canal. Root canal filling therapy can seal the root canal system of a patient, and reduce the recurrence of disease as well as improve the therapeutic effect, which is widely used nowadays. The present root canal filling mainly contains two methods, lateral compaction filling and warm gutta-percha root canal filling, the former of which is mainly performed by lateral compaction. The sealer fit tightly against the canal wall by compaction. However, this method may lead to obvious gaps between master and accessary cones and root canal wall during filling due to the application of cold gutta-percha and lateral compaction filling, resulting in microleakage in apical area. The radiograph may show that three-dimensional filling effect is not obvious and that filling material in root canal is not uniform using lateral compaction filling. Root canal cracking may also present during this filling. For further improvements to the filling therapy, warm gutta-percha root canal filling has emerged in this kind of treatment, which places the flowing heated gutta-percha in the root canal and

reduces the gaps between the gutta-percha and the root canal by vertical compaction, leading to a good filling [16, 17].

In this study, the rate of excellent and good filling in the observation group was 94.7%, and that in the control group was 63.6%. The rate of excellent and good filling in the observation group was significantly higher than that in the control group. The total effective rate of treatment of the control group was significantly lower than that of the observation group. The results of this study are in line with what Liu et al. reported. Liu et al. found that the effective rate of warm gutta-percha root canal filling was 98.99%, which was significantly higher than that of lateral compaction filling [17]. Both studies showed that the treatment effect was much better after using the warm gutta-percha root canal filling. After heating, the flowing gutta-percha is put into the root canals with the help of vertical compaction piece by piece, which makes the gutta-percha reach a close touch with all the gaps of the root canals, leading to a full filling. That is, the flowing gutta-percha can fill accessory canals, lateral canals and curved canals to a better filling, thereby significantly improving the clinical filling.

The VAS score of the observation group was significantly lower than that of the control group. The incidence of adverse reactions in the observation group was significantly lower than that in the control group. The proper filling rate of the observation group was significantly higher than that of the control group. The filling time of the observation group was shorter than that of the control group. Significant differences between the two groups were showed in all the above measurements. Bao et al. found that postoperative pain scores of the warm gutta-percha fillings were significantly lower than that of lateral compaction filling [18]. All the results in both studies showed that the warm gutta-percha filling could increase the proper filling rate, shorten the filling time, and relieve the postoperative pain as well as avoid the occurrence of adverse reactions. Adverse reactions such as swelling of gingivae, leakage of filling materials and looseness of gingivae are often seen after treatment, which can largely be eliminated using warm gutta-percha filling. The warm gutta-percha filling combined with vertical compaction can reduce gaps and infection caused by pathogens in root canals, and reduce leakage of materials due to the seamless connection between root canals and materials.

There was no significant difference in preoperative GI, SBI, and PPD between the two groups. The above three indicators of both groups were significantly decreased after treatment, and the decreases of the observation group were significantly higher than those of the control group. After treatment, IL-1 and TNF-α levels in both groups significantly lowered, and the decreased levels in the observation group were significantly higher than those in the control group. Symptoms of swelling in the gingivae may occur after filling, which may be related to the secretion of inflammatory factors [19, 20]. The overexpression of inflammatory factors in the pulpal and periapical diseases will further damage the periodontium and causes bleeding in the gingivae [21-23]. This study found that warm gutta-percha filling could reduce the level of inflammatory factors, and reduce the GI, SBI and PPD, indicating that this filling could reduce postoperative inflammation and improve protection for the teeth.

In conclusion, application of warm gutta-percha filling in patients with pulpal and periapical diseases can reduce inflammation, improve the treatment effect and eliminate the clinical symptoms of patients, which has a high clinical treatment value and is worthy of application. However, in this study, the filling techniques and the mechanism of pain have not been studied in depth, and the following studies will further explored in these aspects.

Disclosure of conflict of interest

None.

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