Effect of Ultrasonic Irrigation Combined with Epoxy Resin Paste in Single Visit Root Canal Treatment in Chronic Pulpitis

Cheng-Feng Zhang[1], Jing Wang[2], Xin-Yi Zhu[1] and Nan Wang[3]

[1]*Department of Stomatology, Hefei BOE Hospital, Hefei, China*
[2]*Department of Paediatric Dentistry, Hefei Stomatological Hospital, Hefei, Anhui Province, China*
[3]*Department of General Dentistry, Anhui Provincial Dental Hospital, Hefei, China*

ABSTRACT

Objective: To determine the clinical efficacy of ultrasonic irrigation combined with epoxy resin-based sealer in single visit root canal treatment of chronic pulpitis.

Study Design: Randomised controlled trial.

Place and Duration of the Study: Department of Stomatology, Hefei BOE Hospital, Hefei, China, from March 2019 to December 2021.

Methodology: Ninety patients with chronic pulpitis, comprising 104 affected teeth, were enrolled. Using a random number table, they were divided into Group A (n = 30, 35 teeth), Group B (n = 30, 35 teeth), and the control group (n = 30, 34 teeth). All underwent single visit root canal treatment. Group A received ultrasonic irrigation followed by sealing with epoxy resin-based paste; Group B had conventional syringe irrigation followed by the same sealing; the control group had syringe irrigation and closure with zinc oxide-eugenol paste. Pain during treatment, posttreatment clinical outcomes, and differences in inflammatory markers (IL-4, IL-6, hs-CRP), and quality of life (QOL) scores pre- and posttreatment over two months were observed.

Results: After the treatment, improvement rates for Groups A, B, and the control group were 91.4%, 65.7%, and 61.7%, respectively. Pain occurrence rates were 6.7%, 30.0%, and 36.7%, respectively. Group A outperformed both Group B and the control group in improvement and pain incidence with statistical significance ($p<0.016$). Posttreatment, Group A had lower IL-4, IL-6, hs-CRP levels than Groups B and the control group ($p<0.05$), and had higher scores for sleep, mood, and appetite ($p<0.05$).

Conclusion: Ultrasonic irrigation combined with epoxy resin-based paste yields better results for chronic pulpitis treatment, reducing postoperative pain, mitigating inflammation levels, and enhancing quality of life.

Key Words: *Chronic pulpitis, Ultrasonic irrigation, Epoxy resin paste, Root canal treatment, Therapeutic effect.*

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INTRODUCTION

Chronic pulpitis is a prevalent condition in oral health, primarily treated with root canal therapy.[1,2] The typical procedure involves three primary steps: preparation and flushing of the root canal, disinfection, and filling of the canal. While multiple-treatment approaches offer advantages like thorough cleaning due to repeated flushing, they also come with challenges. Extended treatment durations, inconsistent patient compliance, and the risk of secondary infections are notable drawbacks. Consequently, the single visit endodontic treatment has gained traction as it effectively addresses these challenges.

Correspondence to: Dr. Nan Wang, Department of General Dentistry, Anhui Provincial Dental Hospital, Hefei, China
E-mail: wn02050812@163.com

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The success of root canal treatments largely depends on effective cleaning, killing bacteria, and efficient sealing. This is because the primary contributors to endodontic and periapical diseases are bacterial infections and associated inflammatory reactions. Traditional syringe irrigation, due to the intricate anatomy of the root canal system, often falls short in ensuring complete canal cleaning, leading to potential posttreatment infections.

Recent advancements have introduced ultrasonic irrigation as an innovative method for root canal cleaning. This approach utilises the acoustic flow and cavitation effects of ultrasonic waves, enhancing cleaning efficacy.[3] On the filling front, while the zinc oxide-eugenol paste has been a standard, its phenolic content can irritate periapical tissues, possibly leading to inflammation and postoperative discomfort.[4] Epoxy resin-based pastes, a novel filling material, present a promising alternative owing to their superior permeability, stability, and prolonged antibacterial action.[5]

Given this backdrop, this study offered clinical insights into the optimal treatment modalities for chronic endodontitis. Specifi-

cally, the aim of this study was to evaluate and compare the outcomes of single visit endodontic treatments for chronic endodontitis, focusing on the combination of different irrigation methods and root canal filling materials.

METHODOLOGY

From March 2019 to December 2021, the clinical data of 90 patients with chronic pulpitis were collected and analysed in the Department of Stomatology, Hefei BOE Hospital, Hefei, China. The three groups are Group A (treated with ultrasonic rinsing followed by epoxy resin-based paste sealing), Group B (treated with syringe conventional rinsing followed by epoxy resin-based paste sealing), and control group (treated with syringe conventional rinsing followed by zinc oxide clove oil-based paste sealing). The improvement rate of chronic pulpitis of the study object was the main observed outcome index. According to the results of the previous pre-experiment, the treatment rate of Group A was expected to be 92%, the treatment rate of Group B was 65%, and that of the control group was 50%. Set two-tailed $\alpha = 0.05$, the power was 90%. The total sample size of three groups calculated by PASS 15 software was n=90 cases, among which each group had at least 30 subjects. In this study, patient blinding, statistician blinding, data management blinding, result assessment blinding, and other measures were implemented during the research process to blind both patients and researchers.

Inclusion criteria encompassed patients with a clear diagnosis of chronic pulpitis by agreed diagnostic criteria,[6] those having apical formation without resorption, those displaying symptoms as prolonged pain due to cold and hot stimuli or intermittent bouts of dull and aching pain, those fitting the indications for a single visit root sealing,[7] and those demonstrating good compliance with willingness to voluntarily participate in the study. Exclusion criteria was individuals who had undergone previous root canal treatments, those with a combination of multiple periodontal endodontic pathologies, those diagnosed with cognitive or psychiatric disorders, and those with severe heart, brain, liver, or kidney diseases. All patients in this study participated voluntarily and signed an informed consent form. The research protocol was approved by the Hospital's Ethical Committee (No.20190106).

Treatment instruments included multifunctional ultrasound instrument (P5xs, France, Sateri), ultrasonic irrigation needle (#15), apex locator (ProPex II, USA, Densberg), Densberg stainless steel K-file (#15), machine root canal preparation system (X-Smart-Plus, USA, Densberg), machine nickel-titanium file (protaper, USA, Densberg). Experimental reagents are Interleukin-4 (IL-4) kit, Interleukin-6 (IL-6) kit, High-sensitivity C-reactive protein (hs-CRP) kit (Shanghai Ruipan Biotechnology Co., Ltd., China).

The patient was definitively diagnosed *via* an x-ray, which also provided insights into the condition and orientation of the root canal. The patient was placed in a supine position, and a pulpotomy and pulpectomy were performed under the local anaesthesia. The canal was explored and cleared using a #15 K-file. NiTi K-file Sx was employed for coronal enlargement. The Propex II apex locator was used to determine the root canal length. Sequentially, NiTi K-files S1 and S2 reached the working length to prepare the apical part, followed by files F1 and F2 for complete root canal preparation. Throughout the process, 1.7% EDTA lubricant was utilised. Each time an instrument was changed, the canal was thoroughly irrigated with 2.0% sodium hypochlorite (NaOCl) solution. For Group A, ultrasonic irrigation was executed, inserting a #15 ultrasonic file (P5xs, Satelec, France) up to the working length and retracting it by approximately 2mm. This was followed by 1-minute ultrasonic agitation, ensuring minimal contact with the canal walls. Throughout, a continuous rinse with 2.0% NaOCl was maintained. The ultrasonic irrigation needle was set to medium with a flow rate of 20ml/min, as shown in Figure 1. Both Group B and the control group used syringe irrigation, deploying 2.0% NaOCl solution at 20ml, with a flow rate of approximately 5ml/15s, repeated four times. After cleaning, the canal was dried. Epoxy resin-based sealer was used to seal the canal for Group A and B, while the control group utilised a zinc oxide eugenol-based sealer. Postoperative x-rays were taken to assess the quality of the root canal sealing.

Evaluation of therapeutic efficacy was determined based on the periapical index (PAI) proposed by Orstavik.[8] The PAI was scored on a 5-point scale, with scores of 1 and 2 considered normal, and scores of 3 or higher indicating inflammatory changes. Additionally, a comprehensive therapeutic assessment was formulated based on patients' subjective symptoms, including the presence or absence of tenderness upon percussion, tooth mobility, and the restoration of masticatory function. Cure was defined as absence of discomfort, normal masticatory function, no tenderness upon percussion, no significant abnormalities in any clinical examinations, and a PAI score of 1-2. Effective treatment was when the patient reported no discomfort, good masticatory function, no tenderness upon percussion, no significant abnormalities in any clinical examinations, and either an unchanged or decreased PAI score.

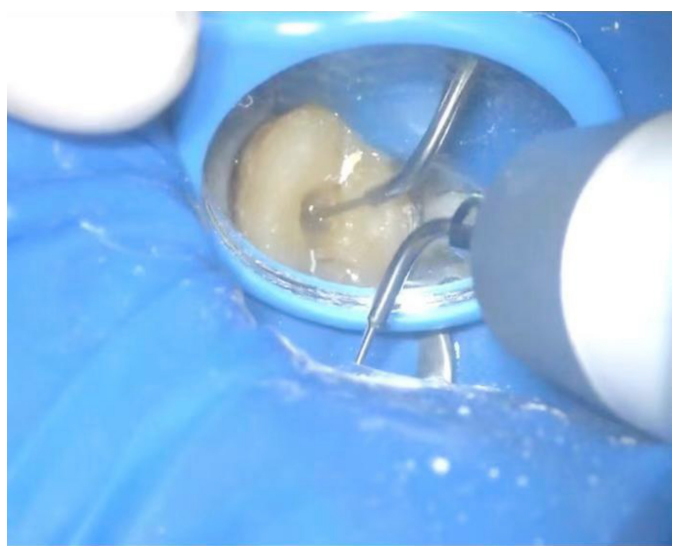

Figure 1: Ultrasonic root canal irrigation.

Table I: Comparison of inflammatory factors in the three groups of patients ($\bar{x}\pm s$).

Group	IL-4 (mg/L)		IL-6 (mg/L)		Hs-CRP (mg/L)	
	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
A group (n=30)	29.74±6.49	50.28±8.54*#	1.68±0.43	1.28±0.34*#	2.39±0.45	1.29±0.35*#
B group (n=30)	30.23±6.33	57.53±7.34*	1.70±0.36	1.54±0.31*	2.25±0.43	1.53±0.37*
Control group (n=30)	30.03±7.11	63.38±8.13	1.66±0.65	1.78±0.43	2.41±0.46	1.85±0.42
F	0.043	20.118	0.077	14.546	1.266	15.932
P	0.958	<0.001	0.926	<0.001	0.287	<0.001

*One-way ANOVA was used for the comparison of multiple groups, and the LSD method was used for comparison between groups. *For comparison with control group, p <0.05; #For comparison with Group B, p <0.05.*

Table II: Comparison of quality of survival scores among the 3 groups of patients (($\bar{x}\pm s$ points).

Group	Sleep		Physical strength		Spirituality		Appetite	
	Before treatment	After treatment	Before treatment	After treatment	Befor treatment	After treatment	Before treatment	After treatment
Group A (n=30)	65.37±5.43	85.33±9.35*#	61.37±5.12	73.43±9.34	63.83±7.23	78.33±8.34*#	65.53±7.45	79.47±8.37*#
Group B (n=30)	64.83±6.34	77.83±8.32*	62.43±7.93	72.13±8.42	62.17±6.46	72.94±8.00*	66.33±8.35	74.03±8.33*
Control group (n=30)	65.40±5.87	71.90±8.67	62.03±8.14	71.65±9.14	62.87±6.87	67.54±8.97	65.93±8.35	68.43±7.35
F	0.087	17.602	0.168	0.321	0.447	12.252	0.074	14.155
P	0.916	<0.001	0.845	0.726	0.641	<0.001	0.929	<0.001

*One-way ANOVA was used for the comparison of multiple groups, and the LSD method was used for comparison between groups.*For comparison with control group, p <0.05; #For comparison with Group B, p <0.05.*

Failure was defined as persistent report of discomfort or pain, clinical examination showing tenderness or pain upon percussion, redness or swelling in the apical region, presence of a sinus tract or palpable pain, and an increased PAI score. Improvement rate was defined as cured + effective / sample size × 100%.

Pain was classified into 4 levels. Grade 0 was no pain or no discomfort; Grade I was mild pain, relieved by itself; Grade II was obvious pain, or pain on percussion, which affected the bite; and Grade III was intense pain, or with local swelling, which required an emergency treatment. Incidence of pain was calculated as (I+II+III)/sample size × 100%.[9] The values of serum IL-4, IL-6 and hs-CRP were measured by ELISA before and 2 months after treatment in the three groups of patients.

The Quality of Living Scale (QOL) was used to evaluate the quality of living, which included 4 dimensions of sleep, physical strength, mental energy and appetite, with a total score of 100 points; the higher the score, the better the patient's quality of life.[10,11]

The IBM-SPSS 18.0 software package was applied for statistical analysis. The measurement data were expressed as mean ± standard deviation ($\bar{x}\pm s$), and one-way ANOVA was used for the comparison of multiple groups, and the LSD method was used for comparison between groups. For categorical data, frequency and percentages were expressed and compared using the Chi-square test, and Bonferroni's method was used to correct for multiple test p-values. A value of p <0.05 was considered a statistically significant difference.

RESULTS

The patients were divided into Group A (n = 30, 35 affected teeth), Group B (n = 30, 35 affected teeth), and control group (n = 30, 34 affected teeth) using the random number table method. The patients' ages ranged from 20 to 55 years, with a mean of 40.28 ± 7.32 years; including 50 males and 40 females; with 27 anterior teeth, 35 anterior molars, and 42 molars, totalling 104. Disease duration ranged from 1 to 5 years, with a mean of 2.23 ± 0.84 years. There were no statistically significant differences between the three groups in terms of general clinical data such as age, gender, disease duration, and location of the affected teeth, which were comparable (p>0.05).

In Group A, B, and the control group, the rates of cured, effective, failure, and overall improvement rate were (37.1%, 54.3%, 8.6%, 91.4%), (28.6%, 37.1%, 34.3%, 65.7%), and (23.5%, 38.2%, 38.2%, 61.7%), respectively. The statistical analysis revealed a significant difference in the improvement rates among the three groups (p = 0.010). Upon further comparison, Group A exhibited a notably higher rate of improvement compared to Group B and the control group (p <0.0167).

After a single vist root canal treatment, the pain levels rated as 0, I, II, III, and the overall incidence of pain in Group A, B, and the control group were 93.3%, 3.3%, 3.3%, 0.0%, 6.7%; 70.0%, 13.3%, 10.0%, 6.7%, 30.0%; and 63.3%, 20.0%, 10.0%, 6.7%, 36.7%, respectively. A significant difference was observed in the pain incidence across the three groups (p = 0.018). Further subgroup analysis revealed that the posttreatment pain incidence in Group A was significantly lower than that in Group B and the control group (p<0.001).

Before treatment, there was statistically no significant difference between the serum IL-4, IL-6, and Hs-CRP expression values in the three groups (p >0.05). After treatment, the expression values of serum IL-4, IL-6 and Hs-CRP were lower in Group A than in Group B and the control group, and the difference was statistically significant (p <0.05). The expression values of serum IL-4, IL-6, and Hs-CRP were lower in Group B than in the control group, and the difference was statistically significant (p <0.05, Table I).

Before treatment, there was statistically no significant difference in sleep, physical strength, mental and appetite scores when comparing the three groups ($p > 0.05$). After treatment, the sleep, mental and appetite scores of patients in Group A were higher than those in Group B and the control group, and the differences were all statistically significant ($p < 0.05$, Table II).

DISCUSSION

Root canal therapy is one of the main treatment for chronic pulpitis, including canal preparation, root canal irrigation, root canal filling. The treatment process is to remove necrotic and infected materials from the system, to thoroughly clean and disinfect them, and then to fill them tightly with filling materials; the key to this treatment is to thoroughly remove necrotic and infected materials from the root canal and to kill pathogenic microorganisms.[12] During root canal treatment, the complexity of the root canal system, whether treated with traditional stainless steel K files or the latest nickel-titanium instruments, still leaves close to one-third of the area uncleaned. Therefore, root canal irrigation and root canal cleaning are of great importance for the treatment outcome.[13,14]

The authors performed endodontic treatment on 90 patients with chronic endodontitis included in the study, and they were divided into control group (syringe rinse + zinc oxide clove oil-based paste), Group B (syringe rinse + epoxy resin-based paste) and Group A (ultrasonic rinse + epoxy resin-based paste) according to different root canal materials and root canal rinsing techniques. It was found that the improvement rate of the epoxy resin-based paste group was significantly higher than that of the control group. Epoxy resin-based root canal paste material is a new material in the recent years, which has the characteristic of high stability, good biocompatibility and long-lasting antibacterial effect compared with the traditional material (zinc oxide clove oil-based paste).[15] Epoxy resin-based paste material filled with continuous low concentration of formaldehyde can play a lasting antibacterial effect, which can effectively prevent root canal infection and improve the efficiency of root canal treatment.[16]

In this study, the improvement rate of patients treated with ultrasonic irrigation + epoxy paste filling was higher than that of patients treated with syringe irrigation + epoxy paste and the control group ($p < 0.05$), indicating that root canal treatment with ultrasonic irrigation was more effective. For this reason, the author believes that since traditional root canal irrigation uses syringe irrigation, which fails to reach at every site due to the complex root canal structure, the syringe irrigation is a weak treatment in removing debris as it cannot completely remove fine debris and pathogenic microorganisms. Ultrasonic flushing technology is a new type of root canal flushing developed in the recent years, which can improve the sterilisation ability and treatment effect through cavitation, acoustic flow, thermal effect, and better dissolution of the lesion tissue, and ultrasound and root canal disinfectant play a synergistic role.[17,18]

Previous studies have found that many patients suffer from pain after root canal treatment, which is mainly caused by root canal deviation, lateral penetration, incomplete root canal cleaning, and missed root canals.[19] All cases in the authors' study were done by the same experienced physician, avoiding pain caused by different operating techniques. The pain profile of the patients in the three groups was as follows: the incidence of pain was lower in the patients with epoxy resin-based paste than in the control group, regardless of their irrigation method, showing that the incidence of pain in epoxy resin-based paste root canal treatment was lower than that in teeth treated with conventional zinc oxide clove oil-based paste. The reason for this was probably related to the small size of epoxy resin-based pastes, which reduced the pain caused by compression due to the filling material. In addition, the coefficient of thermal expansion of epoxy resin-based pastes is close to that of dental tissues, which avoids the pain caused by the pressure of filling materials on periodontal tissues due to temperature changes. The incidence of pain was again lower in patients treated with ultrasonic rinsing + epoxy resin-based paste than in the epoxy resin-based paste group, indicating that ultrasonic rinsing combined with epoxy resin-based paste was effective in reducing the incidence of postoperative pain. The reason may be that the root canals of human premolar and molar teeth are relatively narrow, and syringe flushing cannot thoroughly remove the apical 1 to 3 mm, due to which necrotic tissue and fine debris still remain, while ultrasonic flushing can completely remove the material in the narrow root canals by using the cavity effect and acoustic flow effect, reducing apical embolism and thus, reducing postoperative pain.[20]

Jho *et al*. showed an association between microorganisms in dental plaque and the expression of inflammatory factors in body cells.[21] Vengerfeldt *et al*. found that the root canal lesion area is infiltrated by a large number of lymphocytes and macrophages, which stimulate the release of inflammatory factors in the body cells.[22] The author studied the serum inflammatory factor expression values of three groups of patients and found that the postoperative inflammatory factor of patients with combined ultrasonic irrigation + epoxy resin-like paste filling was lower than that of patients with syringe irrigation, further confirming that ultrasonic irrigation + epoxy resin-like paste filling for root canal treatment can effectively reduce the inflammatory response of the body, and the reduced inflammatory response can also reduce the pain symptoms of patients, while the less severe postoperative pain symptoms will bring patients a higher quality of survival.

The present study had some shortcomings. First, the sample size of this study was relatively small, and there may be a

possibility of selective bias. Secondly, oral diseases are closely related to patients' life and dietary habits, and the patients in this study were all from the Hefei area of China, which may lead to different characteristics of chronic pulpitis in a single population and thus, affect the efficacy of root canal treatment. Finally, the increased treatment cost of ultrasonic flushing compared to the traditional syringe flushing method increases the financial pressure on patients in less developed areas.

CONCLUSION

Ultrasonic irrigation combined with epoxy resin-based paste single visit endodontic treatment of chronic pulpitis is more effective as it can reduce the incidence of postoperative pain, reduce the level of inflammatory response of patients, improve the quality of patient survival, and hence dentists can consider this treatment in the actual work of chronic pulpitis.

ETHICAL APPROVAL:
This study was approved by the Ethics Committee of Hefei BOE Hospital, Hefei, China.

PATIENTS' CONSENT:
Written informed consents were obtained from all patients.

COMPETING INTEREST:
The authors declared no competing interest.

AUTHORS' CONTRIBUTION:
CFZ: Disease diagnosis and treatment, statistical analysis, article writing.
JW: Disease diagnosis and treatment, case follow-up.
XYZ: Disease diagnosis and treatment, case follow-up.
NW: Research design, fund support, personnel coordination, article writing.
All authors approved the final version of the manuscript to be published.

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