Ultrasonic wave's influence on the changes of the number of bacteria in the infected root canal

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Background
We have focused on the making an attempt toward making ultrasonic scaler available for the endodontic treatment and assess the changes in the bacterial numbers in the infected root canal when using it.
Materials and methods
An ultrasonic root canal irrigator was used. A sterilized paper point was inserted in the root canal of the tooth that had been clinically diagnosed as having necrosis of the pulp. After a few minutes, it was suspended in the transport culture medium of 1 ml. This suspension was diluted 10 times and inoculated in the thioglycolate agar medium to calculate the number of alive bacteria.
Results
Ultrasonic irrigation leads to the remarkable reduction in the number of bacteria in the infected root canal, and bactericidal rate was 99.88% and treatment efficacy was 95.6% when combined with canal irrigants.
Conclusion
Ultrasonic wave showed remarkable irrigation effect and higher antibacterial rate when combined with various irrigants; however, it alone cannot kill 100% of bacteria in the infected root canal.

Keywords:
infected root canal, removal of smear layer, ultrasonic irrigation

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Introduction

As the successes of the modern science and technologies have been increasing, the treatment of many disorders has become available, which were previously known to be incurable.

New types of modern instruments have widely been developed in the field of endodontic treatment, including an operation microscope, an ultrasonic instrument, a computerized canal detector, and a mechanical nickel-titanium file.

Particularly, various researchers have focused on wider application and the efficiency of the ultrasound wave and briskly waged investigations.

Ultrasound is an elastic wave with a frequency (2–200 000 Hz) higher than the highest frequency (20 000 Hz) detectable by the human ear. It has several effects including cavity phenomenon, radiation pressure, surface fraction, and absorption, and thus is applied in such fields as irrigation, sterilization, cutting, and diagnosis of diseases [1].

Originally, it was introduced to remove dental plaque and dental calculus, the cause of the periodontopathy, and these days it has been vigorously worked upon to adopt its advances in the endodontic treatment [2]. Using ultrasonic energy in endodontic therapy has improved treatment quality in many aspects, including access to root canal entry holes, cleaning, shaping and filling the canals, eliminating the obstructions and intracanal materials, and endodontic surgery [3,4].

Sterilization of the root canal clinically plays an important role to guarantee the success and prevent recurrence [5]. Oval canal, canal stricture, periapical triangle and other irregular canals, and anatomic complexity make sterilization of canal difficult; thus, many disinfectants have been developed, although there is still controversy [6].

Investigators have been developing different instrument to adopt ultrasonic wave in the irrigation of the canal (ultrasonic instrumentation and ultrasonic scaler combined with blade) and are discussing its efficacy till now [7].

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We have focused on the making an attempt toward making ultrasonic scaler available for the endodontic treatment and assess the changes of the bacteria numbers in the infected root canal when using it.

Materials and methods

Materials

Ultrasonic irrigator for root canal, K-file, stopwatch, 0.5–8% sodium hypochlorite, 1% chlorhexidine, 3% hydrogen peroxide, distilled water cultured bacteria mixture from the infected root canal, transport culture media, liquid paraffin, and anaerobic media (thioglycolate sodium medium) were used for the experiment. This research was ethically approved by the ministry of public health of D.P.R.Korea.

Patients

We have investigated overall 33 patients, including 12 having pulpitis and 21 having apical periodontitis, who were admitted to our hospital from January 2016 to December 2016.

Methods

Extraction of bacteria in infected root canal and its determination

A sterilized paper point was inserted in the root canal of the tooth that had been clinically diagnosed with necrosis of the pulp. After a few minutes, it was suspended in the transport culture medium of 1 ml. This suspension was diluted for 10 times and inoculated in the thioglycolate agar medium to calculate the number of alive bacteria.

Application of ultrasound in the infected canal

The number of the bacteria in the infected canal was calculated ahead of its treatment application.

Changes in the number of bacteria according to the strength of ultrasound wave: the infected canal was exposed to different strength of ultrasound wave for 30 s and later bacteria were extracted by using sterilized paper point and then suspended in the 1 ml of transport medium. This suspension was inoculated in 20 ml of thioglycolate agar medium to calculate the number of alive bacteria.

Changes in the number of bacteria according to the duration of exposure: the number of bacteria was calculated after the exposure to ultrasound wave.

Combination of ultrasonic wave and canal irrigants in the infected canal

Changes in the number of bacteria according to the way of applying irrigants: the canal was irrigated by injecting 5.25% NaOCl and 3% H_2O_2, by combining distilled water with ultrasonic wave and by combining 3% NaOCl and ultrasonic wave. The number of alive bacteria was counted after irrigation.

Determination of the concentration of sodium hypochlorite when combining it with ultrasonic wave

Sodium hypochlorite of different concentrations was applied in the infected canals and then ultrasound wave was exposed followed by irrigation with distilled water. The alive bacteria were extracted with paper point, and their number was counted.

The average frequency of curative procedure after ultrasound irrigation

The number of the curative procedure was counted since the beginning of canal procedure until the canal filling, and its average was calculated.

Evaluation of treatment efficacy

The grade of efficacy was divided into 'remarkable', 'effective', and 'ineffective' and the effective ratio was the sum of 'remarkable' and 'effective'.

Results

Experiment for the application of ultrasonic wave in the infected canal

Changes in the number of bacteria in the infected canal according to the strength of ultrasonic wave

The intracanal bacteria numbers are as follows after applying the ultrasonic wave to the infected canal of various strength for 30 s.

The numbers of bacteria was 140±16.32 CFU/ml at the strength of 5 unit, which was further reduced, and it made no difference even in the higher strength (Table 1).

Table 1 The number of bacteria in the infected canal according to the strength of ultrasonic wave (CFU/ml, n=5)

Original number of bacteria (CFU/ml)	Strength			
	1	5	7	10
37 500±14 361.41	1087.5±42.69* (97.10)	140±16.32 (99.63)	180±16.33 (99.52)	172.5±12.55 (99.55)

*P<0.05 (compared with 5 units). Bactericidal rate/%.

Table 2 The number of bacteria in the infected canal according to the duration of exposure (CFU/ml, *n*=5)

Original number of bacteria (CFU/ml)	Duration/s			
	15	30	60	120
35 000±17 078.25	300±40.0* (99.15)	140±16.33 (99.60)	120±8.16 (99.66)	115±9.57 (99.67)

*$P<0.05$ (compared with 30 s).

Table 3 The number of bacteria in the infected canal according to the way of applying the irrigants (CFU/ml, *n*=5)

Irrigant	Bacteria at 0	Bacteria after irrigation	Bactericidal rate/%
5.25% NaOCl+3% H_2O_2	30 046.6±2341.6	116.0±11.9	99.63
distilled water+ultrasonic wave	28 096.3±17 801.38	160±16.33	99.41
3% NaOCl+ultrasonic wave	30 032.6±10 361.33	48.6±5.6	99.84

Table 4 The number of bacteria in the infected canal according to the concentration of NaOCl (CFU/ml, *n*=4)

Original number of bacteria (CFU/ml)	Concentration/%				
	0.5	1	3	5	10
33 000±17 078.25	120.6±21.88* (99.43)	40±16.33 (99.88)	20±10.16 (99.94)	15±9.57 (99.95)	10±2.88 (99.95)

*$P<0.05$ (compared to 1%). Bactericidal rate/%.

Table 5 Average number of procedure in the infected canal

	N	Average number (mean±SD)
Ultrasound and irrigation	33	2.38±0.10*
Control	31	3.42±0.12

*$P<0.05$ (compare to control group).

Changes in the number of bacteria in the infected canal according to the duration of exposure

The bacteria numbers after applying ultrasonic wave of 5 level strength are shown in Table 2.

Experiment for combining of ultrasonic wave and irrigants.

Changes of the number of bacteria in the infected canal according to the way of applying the irrigants

The bacteria numbers in the infected canal after applying the various irrigants with ultrasonic waves are shown in Table 3.

The bactericidal rate was higher in applying the various irrigants with ultrasonic waves (99.63, 99.84%) than in the simple ultrasound group.

Determination of the concentration of NaOCl while combining with ultrasonic wave

We determined the bacteria numbers after applying NaOCl of different concentration with ultrasonic wave (Table 4).

The bactericidal rate was 99.43% in the 0.5% concentration of NaOCl with ultrasonic wave, and it did not make any difference in the concentration higher than 1%.

The average frequency of curative procedure after ultrasound irrigation

The number of the curative procedure after applying ultrasonic wave (5 units, 30 s) and irrigation with 1% NaOCl was compared with on in the control (Table 5).

Treatment efficacy after ultrasonic irrigation (Table 6): the efficacy in the treatment group (96.9%) was significantly higher than the control (83.8%). ($P<0.05$).

Discussion

Efficacy of ultrasonic wave in the intracanal irrigation was seen.

Ultrasonic devices can be used in two ways: ultrasonic alone and combination with other instrument or medicines.

Ultrasound solely cannot be expected to have perfect bactericidal rate in the infected canal; however, it can guarantee the intracanal sterilization combining with irrigants. When the irrigant is inserted in the prepared canal, the ultrasonic wave is transmitted to the irrigants along the file, thus affecting irrigation and antibacterial through cavity phenomenon and microflows.

Influences of the ultrasonic energy on the intracanal treatment

The success of intracanal treatment relies on the cleaning-irrigation and disinfection of the canal. The aim of the irrigation and disinfection is to guarantee the

Table 6 Treatment efficacy after ultrasonic irrigation

	N	Treatment efficacy			Efficacy rate/%
		Remarkable	Effective	Ineffective	
Control group	31	17	9	5	83.8
Treatment group	33	28	4	1	96.9*

*$P<0.05$ (compare with control group).

antimicrobial status, removal of smear layer, and blockade of canal filling material.

The application of the ultrasonic wave in the intracanal treatment improves the efficacy to the maximum of the irrigant such as NaOCl, which has brilliant antibacterial and tissue dissolution ability and also the blockade of canal filling and success rate of endodontic procedure by removing smear layers.

Conclusion

The bacterial numbers were markedly decreased after infected canal was irrigated with our ultrasonic canal irrigator and the bactericidal rate was 99.88% and the efficacy of treatment was 96.9% when combining ultrasonic wave and irrigants.

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Conflicts of interest
There are no conflicts of interest.

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