Comparison of the removal of calcium hydroxide medicaments on the root canal treatment irrigated with manual and sonic agitation technique

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ABSTRACT

Introduction: Irrigation of the root canal is an important part of the endodontic treatment. Root irrigation technique can be done with the manual and sonic system by using 2.5% NaOCl solution. Calcium hydroxide [$Ca(OH)_2$] is used as a medicament for root canal sterilization. Root canal treatment will fail due to the imperfect removal of $Ca(OH)_2$ residue. The objective of this research was to analyze the comparison of the removal of $Ca(OH)_2$ medicaments on the root canal treatment irrigated with manual and sonic agitation technique using 2.5% NaOCl. **Methods:** The methods used in this study was experimental laboratory. The sample used was 30 maxillary incisors. The teeth were then divided into two groups randomly, then the root canal preparation was done by the crown down technique with irrigation using 2.5% NaOCl. The radicular part of the teeth was then split longitudinally, given a standardized groove in the one-third of the apical part, then applied with water-solved calcium hydroxide. The teeth were unified afterwards by using flowable composites, then soaked in the artificial saliva. The sample of the 1st group was irrigated by manual agitation technique, and the 2nd group by sonic agitation technique. The data results were analyzed by Kruskal-Wallis and Mann-Whitney tests. **Results**: The results of $Ca(OH)_2$ removal were different between manual agitation technique compared to the sonic agitation technique. **Conclusion**: The irrigation using 2.5% NaOCl with the sonic agitation technique were proven to be more effective in removing $Ca(OH)_2$ from root canals than the manual agitation technique.

Keywords: Manual agitation, sonic agitation, irrigation, calcium hydroxide,

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INTRODUCTION

Irrigation of the root canal system is an important part of the principles of endodontic treatment.[1-2] Antimicrobial irrigants that capable of decomposing tissues are considered as an essential part of the cleaning of the chemomechanical debris in biomechanical preparation. After root canal preparation, the remaining pulp tissue, bacteria and debris of the dentin will remain in the inside

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of the root canal that is not instrumented.[2] The cleaning of the root canal is difficult to be done with mechanical preparation because of the complex (irregular) anatomy of the root canal.[2-5] This condition makes the irrigation is an important part of root canal treatment as this technique allows better cleaning of the root canal.

The purpose of irrigation is to remove the pulp tissue and/or the microorganisms (plankton and biofilm) from the root canal. Irrigation should also remove the smear layer, dental debris, and the medicaments residue, after the root canal preparation.[5] The success of irrigation depends on the irrigation techniques, mechanisms and ability to make contact between the irrigants and the elements, materials, and structures inside the root canal that should be discarded.[4-9]

The irrigation technique aims to improve the effectiveness of irrigants in clearing the root canal system (hydrodynamic phenomenon). The most widely used irrigation technique is irrigation with manual agitation technique. Agitation technique is developed into many other techniques, including the sonic agitation technique.[10] Agitation technique will produce hydrodynamic phenomena that will prevent biofilm attachment to the root canal walls. The purpose of the liquid agitation is to produce cavitation, acoustic, and microflows safely on the irrigants in the root canal.[11] Van der Sluis[7] has stated that the flow rate of irrigants was related to the efficiency of the root canal wall cleansing.

Previous research has proved that when an instrument is sonically driven with elliptical movement resulting in pure longitudinal oscillation of files. This type of vibration produces a large amplitude. The flow velocity formula though does not perfectly accounting the conditions inside the root canal, but the larger amplitude exponentially affects the hydrodynamic phenomenon.[1,7,11]

In 1930, Hermann has introduced the calcium hydroxide as a root canal medicament. Calcium hydroxide [$Ca(OH)_2$] is used as an intracanal medicament due to its excellent antibacterial activity against most strains of microorganisms identified in many root canal infections.[12-13] The calcium hydroxide powder was mixed with water or saline and the paste produced was left inside the root canal for several days or weeks.[5] Clinical success of this material is mainly caused by its alkaline pH and its ability of separation into hydroxyl and calcium ions. Tronstad et al.[15] had shown the diffusion of calcium ions through the dentin into the outer surface of the tooth. Calcium hydroxide has been used in various clinical situations and placed inside the root canal for medication for different time periods ranging from 7 days to 6-24 months for apexification.

Calcium hydroxide as a root canal medicament has proven to be able to reduce the number of pathogenic species associated with pulp necrosis. Remaining calcium hydroxide inside the root canal must be removed before the root canal was filled with a permanent filler. Ricucci and Langeland[3] reported a case of failure root canal treatment due to incomplete removal of calcium hydroxide medicament residue. In vitro studies have shown that the calcium hydroxide residue was able to inhibit the penetration of the sealer into the dentinal tubules, thus will inhibit the adhesion of the resin sealer to the dentin, and also will increase the apical leakage in the treated radicular. Therefore, the complete removal of calcium hydroxide from the root canal prior to the root canal filling is necessary. The removal of calcium hydroxide before the final filling was generally done by the irrigation of sodium hypochlorite or saline solution or instrumentation with reaming motion.[13-14]

Sodium hypochlorite (NaOCl) is used generally as an effective endodontic disinfectant because it was able to break down the organic tissue, kills microorganisms, acts as a lubricant and was non-toxic.[5] The objective of this research was to analyze the comparison of the removal of calcium hydroxide medicaments on the root canal treatment irrigated with manual and sonic agitation technique using 2.5% sodium hypochlorite solution.

METHODS

The crown of the extracted maxillary incisors with the straight root were removed in order to obtain a standard root length of 15 mm. The teeth were then immersed in a physiological NaCl solution until the time of the study. Previously, the teeth were cleaned from debris and calculus. Sample

selected were as much as 30 pieces, in accordance with the predetermined criteria. The crown of all teeth fit with these criteria were then cut in accordance with the mark by using Carborundum separating disk. Then, the length of work of the teeth was measured and randomly divided into two groups. The root canal preparation was performed towards the maxillary incisor with the crown down technique up to the #F5 tooth and each file switch was manually irrigated with 2.5 ml of 2.5% NaOCl solution using a 30 gauge irrigation needle.

As the next steps, all samples were marked with the buccopalatal line using a marker, then outlined with a diamond fissure bur. Furthermore, the radicular was split by using chisel and mallet longitudinally into two parts to allow the reassembling process afterwards. Then, a longitudinal groove with the length of 4.0 mm, the width of 0.2 mm, and the depth of 0.5 mm was made with a fine diamond fissure drill with the tip size of 0.2 mm and the diamond coating has been removed from the workpiece except for the 0.5 mm of the apical. The location of the groove was 2 mm in one part of the root piece (apical part) and 14 mm from the working length of the other piece (the crown). One of the hemispheres of the split radicular was given the groove on the one-third of the apical and given the water-solved calcium hydroxide mixed, as seen in Figure 1.

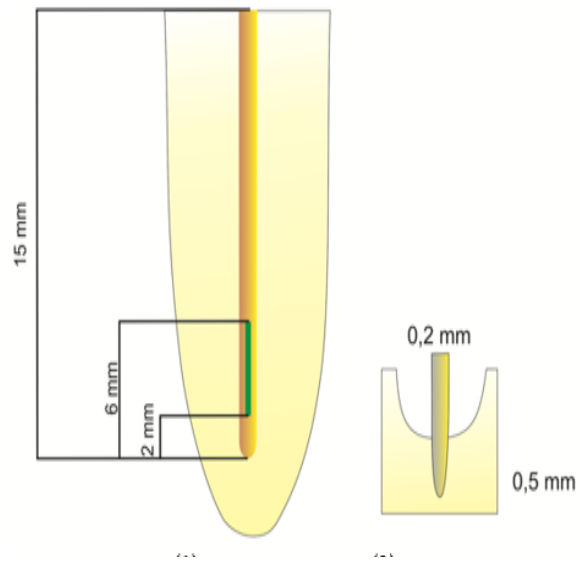

Figure 1. Left: The model of the groove on the root canal as a simulation of irregular radicular anatomy; Right: The latitude section.[12]

Both hemispheres of the tooth then unified using a wire as a tier, the coronal part was applied with a temporal filling, then around the cutting edge of the radicular was given the flowable composite and then cured afterwards. After unified, the radiculars were immersed in the artificial saliva at the temperature of 37°C for 14 days. The samples were divided into two groups, the 1st group was irrigated by the manual agitation technique, and the 2nd group was irrigated by the sonic agitation technique, both were using the 2.5% NaOCl irrigation solution. Then the dental cleavage was observed with a stereo microscope under 24x magnification. The results data then analyzed by Kruskal-Wallis and Mann-Whitney non-parametric tests.

RESULTS

The results from the observation of the removal of calcium hydroxide using a stereo microscope was seen in Figure 2. The assessment of the removal results was done by using a modified Lee[10] score method. Afterwards, the percentage of calcium hydroxide removal was calculated. Furthermore, the Kruskal-Wallis and Mann-Whitney non parametric tests was performed. The measurement results of the observations of calcium hydroxide removal by manual agitation technique were presented in Table 1 and by sonic agitation technique were presented in Table 2.

From the observation of the 1st group, as much as 6 (40.0%) groove samples were found to

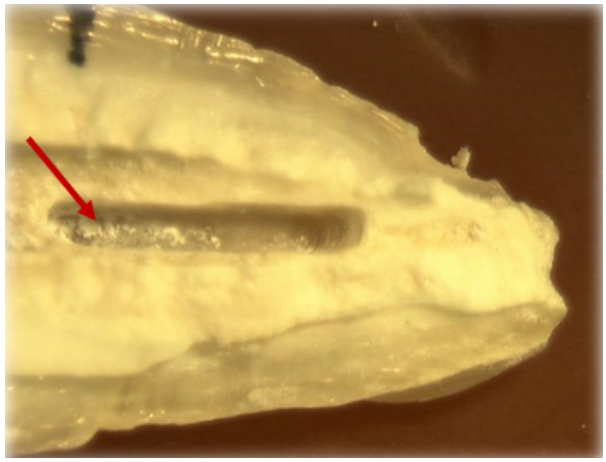

Figure 2. The results of the stereo microscope observation of the groove irrigated with sonic agitation technique

be fully filled with calcium hydroxide and as much as 9 groove samples (60.0%) were found to be half filled with calcium hydroxide. This indicated that most of the groove samples were more than half filled with calcium hydroxide.

From the observation of the 2nd group, as much as 4 groove samples (26.7%) were found to be half filled with calcium hydroxide and as much as 11 groove samples (73.3%) were found to be less than half filled with calcium hydroxide. This indicated that most of the groove samples were less than half filled with calcium hydroxide.

The significant difference of the removal of calcium hydroxide between each group was analyzed by using the Kruskal-Wallis test. The Kruskal-Wallis test results proved that there was a significant difference between each of the observed groups (p = 0.002; presented in Table 3).

From the assessment by modified Lee method[10] obtained the value of X^2 was as much as 17.817. Because the X^2 countable value was as much as 17.817, higher than the table which was as much as 3.841, then Ho is rejected. This value showed that there was a difference in the value of the removal results of the water-solved calcium hydroxide with manual agitation technique and sonic agitation technique.

The Mann-Whitney statistical test was done afterwards in order to differentiate the removal of calcium hydroxide in each group. The results obtained was the value of Z-Mann-Whitney as much as -4.221 with the p value was 0.000. The statistical test results showed that the p value was 0.000, in Table 4. which was lower than 0.05, then the Ho was rejected. Therefore, it can be concluded that there was a change in the value of the calcium hydroxide removal results, which was a decreasing value of removal results with the sonic agitation technique compared to the manual agitation technique.

The average value of the removal results with the manual agitation was 21.80, whilst the average value of the removal results with the sonic agitation was 9.20. This condition showed that there was a decreasing value of removal results with the sonic agitation technique compared

Table 1. The calcium hydroxide removal rate by manual agitation technique

No	Manual agitation irrigation of water-solved calcium hydroxide	f	p
1	Fully filled with calcium hydroxide	6	40.0
2	More than half filled with calcium hydroxide	9	60.0
Total		15	100.0

Table 2. The calcium hydroxide removal rate by sonic agitation technique

No	Manual agitation irrigation of water-solved calcium hydroxide	f	p
1	More than half filled with calcium hydroxide	4	26.7
2	Less than half filled with calcium hydroxide	11	73.3
Total		15	100.0

Table 3. The Kruskal-Wallis test results

Variabel	X Squared Countable	df	X Squared Table	Sig	Conclusion	Notes
The value of the removal results by Lee modification method	17.817	1	3.841	0.000	There was differences	Ho was rejected

Table 4. Mann-Whitney test for both irrigation techniques

Group	Avarage	U	Z Mann Whitney	P	Notes	Conclusion
Samples irrigated with manual agitation technique	21.80	18.000	-4.221	0.000	Ho was rejected	There was differences
Samples irrigated with sonic agitation technique	9.20					

to the manual agitation technique. From the results of this study found that the 2nd group was significantly cleaner than the 1st group.

DISCUSSION

The results of this study indicated that there was a significant difference between the removal of calcium hydroxide using manual agitation and sonic agitation techniques. The removal with the sonic agitation techniques was proven to be more significant and effective than the manual agitation technique. Manual irrigation technique is an irrigation with the lateral perforated needles. The flow of irrigation fluid will flow towards the apical part of the radicular, and returns upward to the coronal part naturally due to the pressure at the time of the irrigation process. Comparing to the manual irrigation technique, the calcium hydroxide removing results by the sonic irrigation technique is more efficient because the sonic vibration system that generates acoustic current during the sonic device is activated. The acoustic current is a rapid movement of liquid particles around the vibrated object. The liquid vibration motion releases calcium hydroxide from the root canal of the groove and therefore, was able to creates a clean irregular root canal.[12-15,16,17]

Devices using the sonic irrigation technique (EndoActivator®, Dentsply®) were also proven to be more efficient in removing the calcium hydroxide than the manual irrigation. This condition is caused by the sonic agitation devices frequency that's ranging from the 160 to 190 Hz. In the principle, higher frequencies will produce higher flow rates. Besides, the flow velocity will also increases along with the increase of the tip oscillation amplitude in a given frequency. Sonic energy generates a significantly higher amplitude, or greater backward-forward tip motion comparing to the ultrasonic instruments.[7,11,18-20]

A research conducted by Nandini et al.[14] in 2006 has found the fact that the mixing agent used to mix the calcium hydroxide paste is essential for the complete removal. The form of water-solved calcium hydroxide powder removed for as much as 96 to 99%, compared to the form of silicon oil-solved calcium hydroxide powder, which only able to get as much as 73 to 89% removal results. The particle form of calcium hydroxide solved in distilled water was able to removed easily but the silicone oil as a solvent was repelled in the water and made it retained in the root canal. Both chelations were efficiently removed the powder form of calcium hydroxide in the water.[14,21,22]

The irrigation material used to remove the calcium hydroxide was able to affected the removal results in the root canal. The 10% concentrate of cytric acid had a better performance than the 17% concentrate of EDTA solution in removing water-solved calcium hydroxide. This condition may caused by the fact that the calcium ion of the EDTA chelation in the water but the citric acid was capable of penetrating silicone oil compared to the EDTA and chelated the calcium ions.[14,19]

In this study, water-solved calcium hydroxide was irrigated using 2.5% of sodium hypochlorite using the manual and sonic agitation irrigation techniques. The root canal samples of this study were still filled with calcium hydroxide recidue that accumulated in the one-third of the apical part with the size of 2-3 mm. The samples irrigated with sonic agitation technique were having more water-solved calcium hydroxide removal than the manual agitation technique irrigated samples. During the sonic agitation, the micro-acoustic flow and cavitation were able to occur causing a hydrodynamic phenomenon inside the root canal from the apical into the coronal part. This hydrodynamic phenomenon caused the higher amount of calcium hydroxide removed from the root canal compared to the use of syringe as an irrigant.

On the research conducted by Van der Sluis[9] in 2006 discovered the fact that the use of sodium hypochlorite as an irrigant was more effective in removing dentin debris of the root canal comparing to the water as an irrigant in passive ultrasonic agitation technique, cause 30% of dentin debris was organic materials that was able to solved really well inside by sodium hypochlorite. In this research, sodium hypochlorite wasn't effective enough on removing calcium hydroxide residue due to its inorganic properties. Sodium hypochlorite was a mineral water suspension. The amount of the bubble of the mineral water was higher, and less vulnerable then the ordinary water bubble. These properties tend to amplifying the microacoustic flow (hydrodynamic phenomenon). The research conducted by Van Der Sluis et al.[8] in 2005 had stated that the root canal with different

size and taper, which were #50, #30, and #20. It was found to be more difficult to removed the dentin debris from the root canal with small size and taper. The average calcium hydroxide removal score from the root canal with the size of 20 and taper of 0.06 was even lower than the dentin debris removal score from smaller root canal in the size of 30 and taper of 0.06. This condition showed the difficulties of the calcium hydroxide removal compared to the dentin debris from the root canal wall. The residual of 36.7% of calcium hydroxide was able to give the negative effect towards the ability of the filler on penetrating the dentin tubules.

The failure of maxillary incisors root canal treatment had been reported due to the failure of the removal of calcium hydroxide medicaments from the canal root apical. A remedial treatment and a removal of calcium hydroxide residue followed by a permanent filling of medication and filler showed periradicular bone healing.[5,8,12-16,18-20,23] Further research regarding the removal of calcium hydroxide using different agitation irrigation technique, different irrigation solution, and different calcium hydroxide solvent was deemed to be necessary. In vivo research also need to be developed regarding the removal of calcium hydroxide inside the root canal.

CONCLUSION

The irrigation using 2.5% NaOCl with the sonic agitation technique were proven to be more effective in removing $Ca(OH)_2$ from root canals than the manual agitation technique.

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REFERENCES

1. Jiang LM, Verhaagen B, Versluis M, Van der Sluis LW. Evaluation of a sonic device designed to activate irrigant in the root canal. J Endod 2010;36(1):143-46. DOI: 10.1016/j.joen.2009.06.009.
2. Rodig T, Bozkurt M, Konietschke F, Hulsmann M. Comparison of the vibringe system with syringe and passive ultrasonic irrigation in removing debris from simulated root canal irregularities. J Endod 2010;36(8):1410-3. DOI: 10.1016/j.joen.2010.04.023.
3. Ricucci D, Langeland K. Incomplete calcium hydroxide removal from the root canal: a case report. Int Endod J 1997;30(6):418–21.
4. Bergenholtz G, Horsted-Bindslev P, Reit C. Textbook of endodontology. 2nd ed. Hoboken: Wiley-Blackwell; 2010.
5. Van der Sluis LW, Gambarini G, Wu MK, Wesselink PR. The influence of volume, type of irrigant anf flushing method of removing artificially placed dentine debris from the apical root canal during passive ultrasonic irrigation. Int Endod J 2006;39(6):472-6. DOI: 10.1111/j.1365-2591.2006.01108.x.
6. Haapasalo M, Shen Y, Qian W, Gao Y. Irrigation in endodontics. Dent Clin North Am. 2010;54(2):291-312. DOI: 10.1016/j.cden.2009.12.001.
7. Van der Sluis LW, Wu MK, Wesselink PR. A comparison between a smooth wire and a K file in the removal of artificially placed dentine debris in plastic blocks. Int Endod J 2005;38(9):593–6. DOI: 10.1111/j.1365-2591.2005.00921.x.
8. Van der Sluis LW, Wu MK, Wesselink PR. The efficacy of ultrasonic irrigation to remove artificially placed dentine debris from human root canals prepared using instruments of varying taper. Int Endod J 2005;38(10):764–8. DOI: 10.1111/j.1365-2591.2005.01018.x.
9. Van der Sluis LW, Versluis M, Wu MK, Wesselink PR. Passive ultrasonic irrigation of the root canal; a review of the literature. Int Endod J 2007;40(6):415-26. DOI: 10.1111/j.1365-2591.2007.01243.x.
10. Lee SJ, Wu MK, Wesselink PR. The effectiveness of syringe irrigation and ultrasonics to remove debris from simulated irregularities within prepared root canal walls. Int Endod J 2004;37(10):672–8. DOI: 10.1111/j.1365-2591.2004.00848.x.
11. Gu LS, Kim JR, Ling J, Choi KK, Pashley DH, Tay FR. Review of contemporary irrigant agitation techniques and devices. J Endod

2009;35(6):791-804. DOI: 10.1016/j.joen.2009.03.010.
12. Ruddle CJ. Hydrodynamic disinfection: tsunami endodontic. Dent Today 2007;26(5): 111-7.
13. Lambrianidis T, Kosti E, Boutsioukis C, Mazinis M. Removal efficacy of various calcium hydroxide/chlorhexideine medicaments from the root canal. Int Endod J 2006;39(1):55-61. DOI: 10.1111/j.1365-2591.2005.01049.x.
14. Nandini S, Velmurugan N, Kandaswamy D. Removal efficiency of calcium hydroxide intracanal medicament with two calcium chelators; volumetric analysis using spiral CT, an in vitro study. J Endod 2006;32(11):1097-101. DOI: 10.1016/j.joen.2006.06.005.
15. Tronstad L, Andreasen JO, Hasselgren G, Kristerson L, Riis I. PH changes in dental tissues after root filling with calcium hydroxide. J Endod 1981;7(1):17–21. DOI: 10.1016/S0099-2399(81)80262-2.
16. Estrela C, Decurcio DDA, de Alencar AHG, Sydney GB, Silva JA. Efficacy of calcium hydroxide dressing in endodontic infection treatment: a systematic review. Rev Odonto Cienc 7 2008;23(1):82–6.
17. Taşdemir T, Celik D, Er K, Yildirim T, Ceyhanli KT, Yeşilyurt C. Efficacy of several techniques for the removal of calcium hydroxide medicament from root canals. Int Endod J 2011;44(6):505–9. DOI: 10.1111/j.1365-2591.2011.01854.x .
18. Vianna ME, Gomes BP, Berber VB, Zaia AA, Ferraz CC, de Souza-Filho FJ. In vitro evaluation of the antimicrobial activity of chlorhexidine and sodium hypochlorite. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2004;97(1): 79–84. DOI: 10.1016/S1079210403003603.
19. Rao SA, Manasa N. Effect of irrigants using ultrasonics on intracanal calcium hydroxide removal–An in vitro comparative evaluation. Braz J Oral Sci 2012;11(1):52-5.
20. Ruddle CJ. Endodontic advancements: game-changing technologies. Dent Today 2009;28(11): 82, 84.
21. Ruddle CJ. "Tsunami" endodontics. Int Dentistry SA 2008;11(4):6–18.
22. Duarte MAH, Ordinola-Zapata R, Bernardes RA, Bramante CM, Bernardineli N, Garcia RB, et al. Influence of calcium hydroxide association on the physical properties of AH Plus. J Endodont [Internet]. 2010;36(6):1048–51. [cited 2012 Oct 11] Available from: http://www.ncbi.nlm.nih.gov/pubmed/20478463.
23. Garg G, Talwar S. Comparison of the efficacy of F file with sonic and ultrasonic debridement to remove artificially placed dentin debris from human root canal-an in vitro study. Endod 2010;22(1);37-45.