The pH and surface tension relationship of various Endodontic Irrigants

Dr. Asit Vats[1], Dr. Anju Bala[2]

[1]Professor & Head, Department of Conservative Dentistry & Endodontics, DJ Dental College of Dental Sciences & Research, Modinagar, Uttar Pradesh, India **(Corresponding author)**

[2]MDS 3rd Year student, Department of Conservative dentistry& Endodontics, PDM Dental College & Research Institute, Bahadurgarh, Haryana, India

Abstract

The physicochemical properties of an endodontic irrigant influences the outcome of root canal treatment. These properties include mainly its composition, concentration, viscosity, surface tension and various factors like surface texture, temperature, pressure, pH, addition of chemical products etc. This article is an attempt to draw a relation between pH and surface tension which enables clinicians to select appropriate irrigants and optimize their effectiveness in disinfection, debris removal, and tissue compatibility during root canal treatment. For this review article, Pubmed, Google scholar and Research gate search engines are used. Keywords like pH, surface tension, endodontic irrigants etc. are used to find the articles. Inclusion criteria is based only on those articles (clinical research, basic research and review) selected which gives direct or indirect relation between pH and surface tension and rest of the articles are excluded which do not end on key points. Most of the articles concluded that acidic pH correlates with lower surface tension and alkaline pH correlates with higher surface tension but a concrete conclusion is still awaited and needs further researches and trials in this field.

Keywords: pH, surface tension, endodontic irrigants.

Introduction

The success of root canal therapy depends on the quality of several factors, including the instrumentation, irrigation, disinfection, and 3-dimensional obturation of the root canal.[1]During the procedure, a steady flow of irrigating solution is used alongside manual and mechanized tools to remove debris, disinfect the canals, and achieve optimal canal shape for subsequent filling but owing to the complexity of root canal morphology (isthmus, deltas, lateral canals etc.) Some intra-radicular areas remain untouched to chemo-mechanical preparation. A possible way of increasing the debridement of root canals that are inaccessible to instrumentation is to improve the delivery and agitation of irrigants.[2]The ideal root canal irrigant should have antimicrobial spectrum, initiate action against biofilms, dissolve pulp and necrotic tissue, inactivate endotoxin, prevent/remove smear layer and not injure the periapical tissue in case of accidental contact.[3] Generally, the physicochemical properties, such as surface tension and pH values of drugs used in root canal therapy must be considered important. The surface tension pertains to the spreading of solutions[4,5] and the hydrogen ion concentration will, to a certain degree, determine the biologic effect.[6] Surface tension (a force between molecules that produces a tendency for the surface area of a liquid to decrease)[7] of a liquid is one of the major factors that affects the wetting of a solid. It has been suggested that higher surface tension may hinder irrigant penetration into dentinal tubules, isthmuses and anatomical irregularities, resulting in reduced antibacterial effectiveness[8] and irrigants with lower surface tension may penetrate more in dental tubules, with greater antimicrobial activity[9]. A neutral pH of the agents used in root canal treatment must be considered appropriate from a biologic point of view. Consequently, the solutions which show very low or very high pH values should be neutralized before use. However, such neutralization must not reduce or destroy the therapeutic properties of the drugs.[10]

Material and Method

Database systems Pubmed, Google Scholar and Research Gate were used to extract the articles.In regards to inclusion criteria, only those articles (original research/ basic research/ case studies/ review aricles) were selected which shows direct or indirect relation between the pH and surface tension. Keywords to search the article were “relation between pH and surface tension of endodontic irrigants”, “impact of changing pH on surface tension”, “chemical properties of various endodontic irrigants”. Exclusion criteria were all other articles which do not end on key point. Approximately103 publications were drawn from these search engines in English language and out of which 16 were selected. Additional information

was obtained from reference list of the selected articles.

Results and Discussion

This section is divided into two parts. 1st part includes those articles which shows no relation between pH and surface tension. 2nd part shows a relation between these two properties. PART I In 1963, Naumovich D.B [10] tried to find out the relationship between pH and surface tension of 22 endodontic irrrigants by means of pH meter, Radiometer and Tensiometer with a 6 cmplatinum-iridium ring but he was unable to establish a concrete relation between these two properties. However, he concluded that the drugs which showed low surface tension values spread more easily in the root canals than those which showed higher values. The difference between EDTA and EDTAC is that Cetavlon (cetyl-trimethyl ammonium bromide) is added to EDTA in order to make it bactericidal. At the same time, EDTAC gets a lower surface tension than EDTA (a difference of 14.3 dynes per centimeter), which should have favoured the spreading. Benzalkonium chloride and chloroform also have low surface tension, and they may spread more easily than, for instance, physiologic saline and 0.5 per cent chloramine which showed a higher surface tension . In 2019, Iglesias JE, Pinheiro LS, Weibel DE et al [11] attempted to find the relation among surfactants, pH and surface tension by means of Du Noüy tensiometer ((Sigma; Attension, Espoo, Finland) and digital pHmeter, (Digimed; São Paulo, São Paulo, Brazil) and concluded that the addition of surfactants to the Ca(OCl)2 solution reduced its surface tension, possibly enhancing its wetting ability, which may enable a better diffusion of the irrigant on dentin walls, leading to improved action of the solution during endodontic treatment .The surfactants on the other hand did not alter the pH of solutions, so they may not affect the properties directly related to it, like antimicrobial activity and pulp dissolution. In 2022, similar findings were also supported by Hernan Coaguila-Llerena, Julia da Silva Toledo, Ana Paula Ramos, et al [12] while working with NaOCl and $Ca(OCl)_2$ and surfactants benzalkonium chloride, cetrimide, Tween 80 and Triton X-100 by using drop shape analysis and digital pHmeter, (DM-22, Digimed, São Paulo,SP, Brazil).

PART II

In 1989, Calve, Medina, Shnchez[13] reported that among the major factors affecting root canal cleansing by EDTA solutions, acidity can be mentioned playing an important role in three possible ways. First, the chelating ability of EDTA increases as acidity decreases[14]. Second, solubility of teeth mineral (hydroxyapatite, HA) increases as pH decreases (on acid medium).[15] Third, pH enhances "the penetrability of EDTA" into small spaces.[16] In 2010, Xiaoli Hu, Junqi Ling , Yan Gao[17] stated that It is well-known that H_2O_2 is a strong oxidant and is also acidic. The increased wettability of the dentin surface is the result of this acidic property of H_2O_2. At low pH increased wettability or low surface tension is advocated by Zeliha Yılmaz, Sevinc Aktemur, Hatice Dogan Buzoglu[18] .They studied the effect of temperature and pH variations on the surface tension of EDTA, REDTA and EDTA-T solutions by means of pendant drop technique using the drop shape analysis system DSA100 (Kr€uss, Hamburg, Germany).They observed the surface tension levels of the EDTA solutions prepared in different pH and temperature values and it was revealed that the pH and temperature variations caused a significant alteration in surface tension levels of these solutions. When prepared at 37°C, EDTA showed the lowest surface tension level at a pH of 5.5 and a significantly increasing level at a pH of 7.5 and 10.5 ($P< .001$). The EDTA-T solution also showed an increased surface tension level at a pH of 7.5 and 10.5. The REDTA solution was stable at a pH of 5.5 and 7.5, whereas it showed a significantly lower surface tension level at a pH of 10.5. In 2011, Meenu G Singla, Ashima Garg, Sumit Gupta[19] stated that MTAD has a low pH and acts as a calcium chelator and causes enamel and root surface demineralization[20] and because of the low surface tension of MTAD (34.5 mJ/m2),[21] the intimate contact of irrigant solutions with the dentinal walls might increase, which may permit deeper penetration for effective smear layer removal and thereby disinfection.

In 2016, Natalia Gomes e Silva Leonardo, Israel Bangel Carlotto ,Simone Bonato Luisi [22] studied the pH and the available chlorine content from sodium hypochlorite (NaOCl) and calcium hypochlorite (Ca[OCl]2) solutions stored in different conditions and time periods .The surface tension of Ca(OCl)2 solutions in comparison with NaOCl was also tested by means of digital pH meter (Digimed, S~ao Paulo, SP, Brazil) and the Du Nouy tensiometer (Sigma 702, Force Tensiometer; Attension, Espoo, Finland). They found that Ca(OCl)2 solutions are extremely alkaline and tend to have more available chlorine content than NaOCl but have a higher surface tension compared with NaOCl solutions with the same concentration. They also found thatfreshly prepared 0.5% and 1% NaOCl solution have a lower pH value compared with Ca(OCl)2 with the same concentration. In 2016 Luciano Giardino, Flaviana Bombarda de Andrade , Riccardo Beltrami[23] also reported the better antibacterial action of Tetraclean NA. This may be explained by its low pH, low surface tension and better removal of the smear layer, all of which improves it's

penetration into the root canal and the dentinal tubules.

Conclusion

It is well known fact that the root canal therapy is unsuccessful without effective endodontic irrigants but to choose a suitable root canal irrigant is also a difficult task. This hurdle can be removed if we know all the physical and chemical properties of the irrigant while using it. Different methods, variety of chemicals and equipments/ instruments of different brands with different calibrations are used while performing the procedures. Moreover, all procedures are technique sensitive and any micro-error can change the expected outcome. Hence, a clear cut relation is still to be found,but on the basis of researches, trials and experiments it can be derived that if an endodontic irrigant has an acidic pH then it has low surface tension which also leads to enhanced spreading and penetrability of the liquid into dentinal tubules. This field is still open for further researches.

References

1. Eldeniz AU, Erdemir A, Belli S. Effect of EDTA and citric acid solutions on the microhardness and the roughness of human root canal dentin. J Endod 2005;31:107–10
2. Gu LS, Kim JR, Ling J, et al. Review of contemporary irrigant agitation techniques and devices. J Endod 2009;35: 791–804.
3. Haapasalo M, Shen Y, Wang Z, et al . Irrigation in endodontics. Br Dent J. 2014;216(6):299-303.
4. Evans, L. Ch.Principles of Human Physiology, ed. 2, London, 1952. J. & A. Churchill, Ltd., pp. 62-68.
5. March, T. Some Physico-Chemical Factors, Dissertation paper, Drammen, Norway, 1954, Harold Lyche & Co.
6. Berger, B. Biological Means for root canal therapy. Stom. glas. Srbije, Belgrade, No. 4, pp. 25-31, 1958.
7. Cameron JA. The effect of a fluorocarbon surfactant on the surface tension of the endodontic irrigant, sodium hypochlorite. A preliminary report. Aust Dent J 1986;31:364–8
8. Palazzi F, Morra M, Mohammadi Z,et al . Comparison of the surface tension of 5.25% sodium hypochlorite solution with three new sodium hypochlorite-based endodontic irrigants. Int Endod J 2012; 45: 129–35.
9. Rossi-Fedele G, Prichard JW, Steier L, et al . The effect of surface tension reduction on the clinical performance of sodium hypochlorite in endodontics. Int Endod J 2013;46(6):492-8.
10. Naumovich D.B . Suface tension and pH of Drugs in Root canal therapy. Oral Surg Oral Med Oral Pathol 1963; 16:965-8
11. Iglesias JE, Pinheiro LS, Weibel DE et al. Influence of surfactants addition on the properties of calcium hypochlorite solutions. J Appl Oral Sci 2019;27:e20180157.
12. Hernan Coaguila-Llerena, Julia da Silva Toledo, Ana Paula Ramos, et al. Physiochemical properties and penetration into dentinal tubules of calcium hypochlorite with surfactants. Braz Dent J 2022;33(2):1-11
13. Calve, Medina, Shnchez. Changes in pH during EDTA demineralization of teeth. Oral Surg Oral Med Oral Pathol 1989; 68:220-2
14. Dwyer FP, Mellor DP. Chelating agents and metal chelates. New York: Academic Press, 1964:283-333.
15. Theuns HM, Van Dijk JWE, Driessens FCM, et al . Effect of time, degree of saturation, pH and acid concentration of buffer solutions on the rate of in vitro demineralization of human enamel. Arch Oral Biol 1985;30:37-42.
16. Ravnik C, Sand HF, March T. Enamel lesions produced in vitro by solutions of EDTA and EDTA-sodium salts. Acta Odontol Stand 1962;20:349-58.
17. Xiaoli Hu, Junqi Ling, Yan Gao. Effects of irrigation solutions on dentin wettability and roughness. J Endod 2010; 36:6
18. Zeliha Yılmaz, Sevinc Aktemur, Hatice Dogan Buzoglu ,et al .The Effect of Temperature and pH variations on the surface tension of EDTA solutions. J Endod2011; 37: 6
19. Meenu G Singla, Ashima Garg, Sumit Gupta. MTAD in endodontics: an update review. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;112:e70-e76
20. Björvatn K, Skaug N, Selvig KA. Tetracycline-impregnated enamel and dentin: duration of antimicrobial capacity. Scand J Dent Res 1985;93:192-7.
21. . Giardino L, Ambu E, Becce C, et al . Surface tension comparison of four common root canal irrigants and two new irrigants containing antibiotic. J Endod 2006;32:1091-3
22. Natalia Gomes e Silva Leonardo, Israel Bangel Carlotto ,Simone Bonato Luisi. Calcium Hypochlorite Solutions: Evaluation of surface tension and effect of different storage conditions and time

periods over pH and available chlorine content. J Endod 2016;42(4):641-5
23. Luciano Giardino, Flaviana Bombarda de Andrade, Riccardo Beltrami. Antimicrobial effect and surface tension of some chelating solutions with added surfactants. Braz Dent J 2016; 27(5): 584-588