Why We See PROBLEMS with Teeth WHITENING: The Science of Whitening Part IV – Whitening Sensitivity Solutions

by Rod Kurthy, DMD

In the last three articles* you've learned about the science of teeth whitening, why problems occur and about how to overcome obstacles to whitening. In this fourth and final article of this series, Dr. Kurthy will discuss how the science of whitening sensitivity can be utilized to reduce the incidence of whitening sensitivity and the steps he has taken to utilize this science.

Science-Based Solutions to Whitening Sensitivity

Solutions to teeth whitening sensitivity include the following:

1. Creation of whitening gels with the lowest osmolality possible, to reduce the osmotic gradient between whitening gel and dentinal tubular fluid, thereby reducing intratubular fluid flow and sensitivity.[16,17,33,34,63,66,80,81,91-93]

a. Whitening gels should not only be aqueous,[16] but 100 percent aqueous (lowest possible osmolality[17,80,91-93]). To extend shelf life and aqueous gel stability during storage, constant refrigeration must be used instead of the use of anhydrous gels[3,8,14-16,30,32] (anhydrous gels have much stronger osmolality).

b. Whitening gels should be entirely neutral or even slightly alkaline (lowest possible osmolality[17,80,91-93]).[16,89] To extend shelf life and neutral gel stability during storage, constant refrigeration must be used instead of adding acidifiers to whitening gels[3,8,14-16,30,32] (acidified gels have much stronger osmolality).

By utilizing constant refrigeration to lengthen shelf life, instead of using the mentioned chemical stabilizing, not only are the whitening gels more unstable (more effective[14-17]) when placed in the warm mouth, but the osmolality can be as little as 1/11th that of gels that are chemically stabilized.[17,80,91-93] That means 11 times less pull on the dentinal tubular fluid, and therefore significantly less sensitivity.

* Visit www.dentaltown.com/rodkurthy to view the three previous articles.

3. *Christensen G, Tooth Bleaching, State-of-Art '97. Clinical Research Associates Newsletter 1997;21(4).*
8. *McCaslin AJ, Haywood VB, Potter BJ, Dickinson GL, Russell CM. Assessing dentin color changes from nightguard vital bleaching. Journal of the American Dental Association. 1999;130.*
14. *Andrea Freire, Lucí Regina Panka Archegas, Evelise Machado de Souza, Sérgio Vieira. Effect of storage temperature on pH of in-office and at-home dental bleaching agents. Vol. 22 Nº 1 / 2009 / 27-31 ISSN 0326-4815 Acta Odontol. Latinoam. 2009*
15. *Scientific Committee on Consumer Products (SCCP). Opinion on hydrogen peroxide in tooth whitening products 2005.*
16. *Margeas RC. New advances in tooth whitening and dental cleaning technology. The Academy of Dental Therapeutics and Stomatology Dental Continuing Education Peer-Reviewed Web site. Accessed 2010;March.*
17. *Papathanasiou A, et al. Clinical evaluation of a 35% hydrogen peroxide in-office whitening system. Comp. 2002;23:335–346.*
30. *Greenwall, L. Bleaching Techniques in Restorative Dentistry. Martin Dunitz. London: 2001.*
32. *Chang, R. Quimica. Lisboa (Port): McGraw-Hill; 1994.*
33. *Gillam DG, Aris A, Bulman JS, et al. Dentine hypersensitivity in subjects recruited for clinical trials: clinical evaluation, prevalence and intra-oral distribution. J Oral Rehabil. 2002;29.*
34. *Drisko CH. Dentine hypersensitivity: dental hygiene and periodontal considerations. Int Dent J. 2002;52:385-393.*
63. *Marvin K. Bright, White, and Sensitive: An Overview of Tooth Whitening and Dentin Hypersensitivity. Dentistry Today.com. 2009 Sept.*
66. *Pashley DH, Tay FR, Haywood VB, Collins MA, Drisko CL. DENTIN HYPERSENSITIVITY: Consensus-Based Recommendations for the Diagnosis & Management of Dentin Hypersensitivity. Inside Dentistry (supp). 2008 Oct: 4(9) (special issue).*
80. *Abd-Elmeguid A, Yu DC. Dental Pulp Neurophysiology: Part 1. Clinical and Diagnostic Implications. JADC. 2009;75(1):55.*
81. *Braennstroem M, Astroem A. A study on the mechanism of pain elicited from the dentin. J Dent Res. 1964;43:619–25.*
89. *Reeder OW Jr, Walton RE, Livingston MJ, Pashley DH. Dentin permeability: determinants of hydraulic conductance. J Dent Res. 1978 Feb;57(2):187-93.*
91. *Anderson DJ, Matthews B, Shelton LE. Variations in the sensitivity to osmotic stimulation of human dentine. Arch Oral Biol. 1967; 12(1):43–7.*
92. *Narhi M, Kontturi-Narhi V, Hirvonen T, Ngassapa D. Neurophysiological mechanisms of dentin hypersensitivity. Proc Finn Dent Soc. 1992; 88 Suppl 1:15–22.*
93. *Narhi MV, Hirvonen T. The response of dog intradental nerves to hypertonic solutions of CaCl2 and NaCl, and other stimuli, applied to exposed dentine. Arch Oral Biol. 1987;32(11):781–6.*

2. Prevention of dentinal hypersensitivity during whitening with rapid, aggressive occlusion of dentinal tubules, before and after each whitening activity instead of treating symptoms after they occur. Part III of this series discussed commonly used desensitizers that take time to either enter the pulp or plug the dentinal tubule orifice. With whitening sensitivity, we need desensitizing to work now! We need instantly effective desensitizing products and protocols. Reinforcement of tubular smear plugs immediately prior to whitening, and rapid, aggressive replacement of any smear plugs lost during the oxygenation phase of whitening immediately after each whitening session results in predictably less sensitivity.[80, 87,113]

3. Prevention of zinger-type whitening sensitivity with rapid, aggressive occlusion of enamel and dentin aberrations before and after each whitening activity. According to the hypothesis of zinger etiology presented in Part III of this series, prevention of molecular hydrogen peroxide into the pulp would prevent whitening zingers.[125]

4. Use of desensitizer before and/or after whitening, but not mixed in with the whitening gel itself.[73-77] Remember the discussion in the previous article (Part III) regarding how the aggressive oxygenation during whitening will interfere with the formation of tubular plugs during whitening,[73-77,125] and how the tubular flow during whitening is outward from the pulp,[16,80,91-93] making it more difficult for desensitizers to "swim upstream" into the pulp.[80,91-93]

5. Avoidance of bleaching lights or lasers. Numerous studies have proven the ineffectiveness of bleaching lights and lasers.[48,55-60] With the ability to predictably accelerate whitening gels via pH and chemical acceleration,[58,59] there is no need to consider the use of potentially harmful bleaching lights or lasers.[16,17,49,62,80] Remember from Part III that bleaching lights and lasers (photon energy) plus high concentration peroxide cause

Fig. 1: Hydrogen Peroxide (H2O2) is the active end product of all peroxide whitening systems. H2O2, depending on the whitening gel storage temperature, whitening tray environment and whitening gel chemistry, may break down to ineffective oxygen and water, or it may break down to effective bleaching factors including free radicals. When radicals are produced, hydrogen ions (acid) are also produced. [10,13,16,26-30,96]

significant increase in substance P, resulting in much stronger, and sometimes downright painful, whitening sensitivity.[49,125]

6. Use of buffering agents to stabilize the neutral pH of whitening gels during decomposition in the mouth, preventing the natural tendency of peroxides to rapidly become acidic. Remember from the previous articles in this series that when peroxide breaks down to effective whitening radicals, hydrogen ions (acid) are also produced in high numbers (Fig. 1).[10,13,16,26-30,96]

KöR Whitening Sensitivity Solutions

KöR Whitening has utilized the listed solutions to whitening sensitivity based on the known science previously discussed.

10. *Goldberg M, Bohin F, Bonnet E, Claisse-Crinquette A, Dartigues J, Louis J. TOOTH BLEACHING TREATMENTS: A Review. Association Dentaire Française, Paris. 2005.*
13. *Dahl J, Pallesen U. Tooth bleaching—a critical review of the biological aspects. Critical Reviews in Oral Biology & Medicine. 2003 14(4).*
26. *Sulieman M. An overview of bleaching techniques: I. History, chemistry, safety and legal aspects. Dent Update. 2004;31.*
27. *Hannig C, Zech R, Henze E, Dorr-Tolui R, Attin T. Determination of peroxides in saliva: kinetics of peroxide release into saliva during home-bleaching with Whitestrips and Vivastyle. Arch Oral Biol. 2003;48.*
28. *Cotton FA, Wilkinson G (1972). Oxygen. In: Advances in inorganic chemistry. A comprehensive text. Cotton FA, Wilkinson G, editors. New York: Interscience Publisher.*
29. *Madhu C, Gregus Z, Klaassen C D. Simple method for analysis of diquat in biological fluids and tissues by high-performance liquid chromatography. Journal of Chromatography. B, Biomedical Applications. 1995;674(2).*
48. *Lima DA, Aguiar FH, Liporoni PC, Munin E, Ambrosano GM, Lovadino JR. In vitro evaluation of the effectiveness of bleaching agents activated by different light sources. J Prosthodont. 2009 Apr;18(3):249-54.*
49. *Caviedes-Bucheli J, Ariza-García G, Restrepo-Méndez S, Ríos-Osorio N, Lombana N, Muñoz HR. The effect of tooth bleaching on substance P expression in human dental pulp. Journal of Endodontics. 2008 Dec;34(12):1462-5.*
55. *Bruzell EM, Johnsen B, Aalerud TN, Dahl JE, Christensen T. In vitro efficacy and risk for adverse effects of light-assisted tooth bleaching. Photochem Photobiol Sci. 2009 Mar;8(3):377-85.*
56. *Christensen GJ. New Generation In-office Vital Tooth Bleaching, Part 2. Clinical Research Associates (CRA) Newsletter. 2003 March:27(3):1-3*
57. *Haywood, V. Masters of Esthetic Dentistry. Journal of Esthetic and Restorative Dentistry. 2003;15(3).*
58. *Hein DK, Ploeger BJ, Hartup JK, Wagstaff RS, Palmer TM, Hansen LD. In-office vital tooth bleaching--what do lights add? Comp Contin Edu Dent. 2003 Apr;24(4A):340-52.*
59. *Kugel G, Papathanasiou A, Williams AJ 3rd, Anderson C, Ferreira S. Clinical evaluation of chemical and light-activated tooth whitening systems. Compend Contin Educ Dent. 2006 Jan;27(1):54-62.*
60. *Jones AH, Diaz-Arnold AM, Vargas MA, Cobb DS. Colorimetric assessment of laser and home bleaching techniques. J Esthet Dent. 1999;11(2):87-94.*
62. *Olgart L. Neural control of pulpal blood flow. Crit Rev Oral Biol Med. 1996;7(2):159–71.*
73. *Christensen GJ. At-Home Tooth Bleaching, State-Of-Art 2001. Clinical Research Associates (CRA) Newsletter. 2001 Feb;25(2):2-4*
74. *Gallo JR, Burgess JO, Ripps AH, Bell MJ, Mercante DE, Davidson JM. Evaluation of 30% carbamide peroxide at-home bleaching gels with and without potassium nitrate – a pilot study. Quintessence Int. 2009 Apr;40(4):1-6.*
75. *Tschoppe P, Neumann K, Mueller J, Kielbassa AM. Effect of fluoridated bleaching gels on the remineralization of predemineralized bovine enamel in vitro. J Dent. 2009 Feb;37(2):156-62. Epub 2008 Dec 11.*
76. *Matis BA, Cochran MA, Eckert GJ, Matis JI. In vivo study of two carbamide peroxide gels with different desensitizing agents. Oper Dent. 2007 Nov- Dec;32(6):549-55.*
77. *Giniger M, Spaid M, MacDonald J, Felix H. A 180-day clinical investigation of the tooth whitening efficacy of a bleaching gel with added amorphous calcium phosphate. J Clin Dent. 2005;16(1):11-6.*
87. *Absi EG, Addy M, Adams D. Dentine hypersensitivity. A study of the patency of dentinal tubules in sensitive and non-sensitive cervical dentine. J Clin Periodontol. 1987 May;14(5):280-4.*
96. *Eary LE. Catalytic decomposition of hydrogen peroxide by ferric ion in dilute sulfuric acid solutions Metallurgical and Materials Transactions B. 1985 June; 16(2):181-186.*
113. *Byers MR. Effects of inflammation on dental sensory nerves and vice versa. Proc Finn Dent Soc. 1992;88 Suppl 1:499–506.*
125. *Kurthy R. Why We See Problems with Teeth Whitening: The Science of Whitening - Part III -Whitening Sensitivity. DentalTown Magazine. 2013 Jan.*

continued on page 98

 continued from page 97

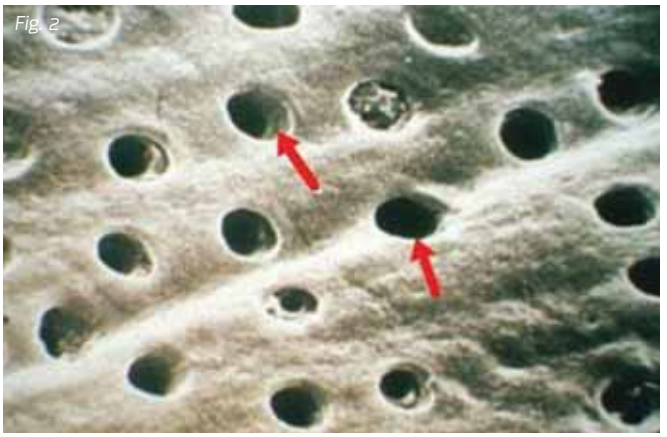

Fig. 2: SEM photograph showing opened dentinal tubular orifices. Hydraulic conductance is 32 times greater than occluded tubules,[87,89] tubular fluids are exposed to various stimuli capable of creating tubular fluid flow, resulting in tooth sensitivity and pain.[16,17,66,79-81]

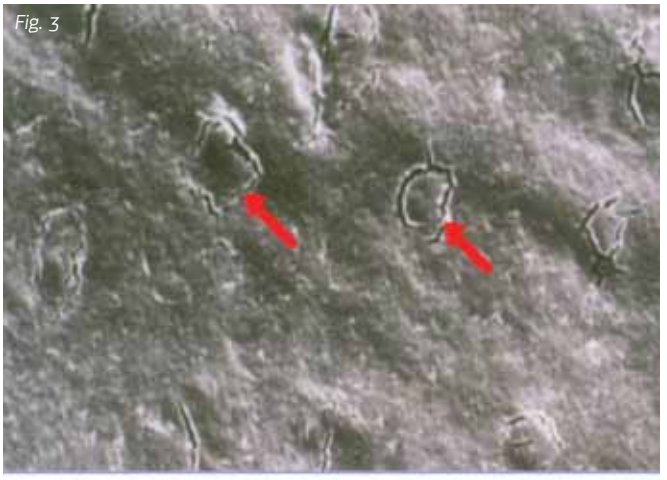

Fig. 3: SEM photograph showing dentinal tubular orifices closed by an Evolve Dental Technologies KöR Desensitizer. Hydraulic conductance has been eliminated and tubular fluids are prevented from contact by stimuli, including whitening gels, resulting in the reduction or prevention of sensitivity.[87,88]

1) Reducing the "Pull" on Dentinal Tubular Fluid

KöR Whitening is the first teeth whitening company to refrigerate a full line of whitening gels from the instant of manufacture until dental offices receive the whitening gels cold. By using refrigeration as the stabilizer of the product instead of chemical stabilizers, not only is the shelf life even longer, but the whitening gel is even more unstable (more effective[14-17]) when placed in the warm mouth and has as little as 1/11th the osmolality of products using chemical stabilizers.[17,66,80,81,91-95]

The much lower osmolality greatly reduces the "pull" on dentinal tubular fluid, reducing whitening sensitivity.[17,66,80,81,91-95]

2) Keeping Dentinal Tubules Closed

The science shows that rapid profound closure of dentinal tubules, immediately before and after whitening procedures, results in the most predictable whitening sensitivity control possible.[73,76,77]

KöR utilizes desensitizers that instantly plug dentinal tubules (Figs. 2 and 3).[66,126,127,129-134] The primary KöR Desensitizer is a HEMA- (hydroxyethyl methacrylate) based desensitizer. HEMA is a hydrophilic dentin bonding derivative – a resin primer. HEMA-based desensitizers bind with proteins within dentinal tubules to form organic plugs within the tubules.[66,126-128] The result is immediate and profound.[66,126,127,129-134]

HEMA-based desensitizers have a long history of successful, immediate desensitizing via occlusion of dentinal tubules,[66,126,127,129-134] and are well supported by years of research.[126,127,129-134] HEMA-based desensitizers provide rapid, aggressive plugging and replugging of tubules,[66,126,127,129-134] with no reduction in whitening effectiveness whatsoever (Figs. 4 and 5).

To understand the importance of this desensitizing protocol, remember that the oxygenation phase of any type or brand of peroxide whitening will dislodge natural and synthetic tubular smear plugs, resulting in open dentinal tubules.[123,124] This is one of the reasons that whitening sensitivity is common. This increases the hydraulic conductance (discussed in Part III of this a series) by 32-fold, greatly increasing whitening sensitivity.[87,89]

To reduce the loss of smear plugs during whitening, it is important to "supercharge" the smear plugs prior to whitening; and realizing that some smear plugs will be lost during whitening,[123,124] it is important to replug these tubules immediately after

79. *Brännström M. A hydrodynamic mechanism in the transmission of pain-produced stimuli through the dentine. In: Sensory Mechanisms in Dentine. Anderson DJ, ed. pp 73-79. Pergamon Press. London, 1963.*
88. *Yoshiyama M, Noiri Y, Ozaki K, Uchida A, Ishikawa Y, Ishida H. Transmission electron microscopic characterization of hypersensitive human radicular dentin. J Dent Res. 1990;69:1293-7.*
94. *Vongsavan N, Matthews B. The relationship between the discharge of interdental nerves and the rate of fluid flow through dentine in the cat. Arch Oral Biol. 2007 Feb;52(7):640–7.*
95. *Pashley DH. Sensitivity of dentin to chemical stimuli. Endod Dent Traumatol. 1986; 2(4):130–7.*
123. *Speronello B, Castellana F. Tooth Whitening Compositions and Methods. US patent application. Application # 20110229422. 09/22/2011.*
124. *Strassler H. The Science and Art of Tooth Whitening. The Academy of Dental Therapeutics and Stomatology. Penwell Corp. 2009.*
126. *Kolker JL, Vargas MA, Armstrong SR, Dawson DV. Effect of desensitizing agents on dentin permeability and dentin tubule occlusion. J Adhes Dent. 2002 Fall;4(3):211-21.*
127. *Duran I, Sengun A, Yildirim T, Ozturk B. In vitro dentine permeability evaluation of HEMA-based (desensitizing) products using split-chamber model following in vivo application in the dog. J Oral Rehabil. 2005 Jan;32(1):34-8.*
128. *Study by Selim Product Development Services, Inc., Moffett Campus, Summit-Argo, Il*
129. *Aranha AC, Pimenta LA, Marchi GM. Clinical evaluation of desensitizing treatments for cervical dentin hypersensitivity. Braz Oral Res. 2009 Jul-Sep;23(3):333-9.*
130. *Ishihata H, Kanehira M, Nagai T, Finger WJ, Shimauchi H, Komatsu M. Effect of desensitizing agents on dentin permeability. Am J Dent. 2009 Jun;22(3):143-6.*
131. *Kakaboura A, Rahiotis C, Thomaidis S, Doukoudakis S. Clinical effectiveness of two agents on the treatment of tooth cervical hypersensitivity. Am J Dent. 2005 Aug;18(4):291-5.*
132. *Duran I, Sengun A. The long-term effectiveness of five current desensitizing products on cervical dentine sensitivity. J Oral Rehabil. 2004 Apr;31(4):351-6.*
133. *Camps J, Pizant S, Dejou J, Franquin JC. Effects of desensitizing agents on human dentin permeability. Am J Dent. 1998 Dec;11(6):286-90.*
134. *Camps J, About I, Van Meerbeek B, Franquin JC. Efficiency and cytotoxicity of resin-based desensitizing agents. Am J Dent. 2002 Oct;15(5):300-4.*

each whitening session.[11,73-77,125] This applies to both in-office whitening and at-home whitening.

KöR desensitizers are applied to the patient's teeth in the dental practice immediately before and after any in-office whitening session. They are not mixed in with the whitening gels. KöR Desensitizer, which is included in all at-home patient kits, is approved for at-home daily use by patients. Patients use this desensitizer daily after each at-home whitening to replug any tubules that may have been opened by the oxygenation process of whitening.[126,127]

3) Closing Tooth Structure Aberrations that Allow Peroxide to Enter the Pulp

Many agree that split-arch clinical testing is the most accurate for whitening studies,[135-138] as well as sensitivity studies. With split-arch studies, one process and/or product is used on one side of the patient's arch, and another (often the control) is used on the opposite side of the same patient's arch. After the testing process, it is very simple to see any difference in the sides, and to ask the patient regarding sensitivity felt. When numerous patients are tested this way, the results are very accurate and convincing.

Our split-arch studies of the KöR Desensitizer showed a 90 percent decrease of not only type 1 generalized whitening sensitivity, but also a 90 percent decrease in type 2 zinger-type whitening sensitivity. Given the hypothesis of zinger-type 2 whitening sensitivity etiology presented in Part III of this article series,[125] it may be assumed that the

Fig. 4: Pre-op – Participant in KöR Desensitizer clinical testing

Fig. 5: Post-op – KöR Desensitizer was used on the patient's right side immediately prior to and immediately after the whitening procedure. No desensitizer was used on the patient's left side. KöR Desensitizer did not impede whitening. Whitening results are identical on both sides.

Fig. 6: KöR Dual Activated, Tri-Barrel Hydremide Peroxide in-office whitening gel. Three sets of three syringes (A-C). Each set of three syringes is mixed and applied to the teeth for 20 minutes.

KöR Desensitizer, in addition to plugging open dentinal tubules, may also plug aberrations in tooth structure that would otherwise allow molecular hydrogen peroxide access to the pulp. At this point you may have the same question and concern that I originally had, wondering if this same KöR Desensitizer, with its "plugging" capability, may actually impair the effectiveness of whitening.

To objectively answer this concern, we performed numerous split-arch clinical cases. Patients were treated with both in-office and at-home whitening. Both types of whitening were accomplished on both sides of the patients' arches, however, prior to and immediately after whitening, KöR Desensitizer was applied to only one side of the patients' arches. In every case, the whitening results appeared exactly the same on both sides of these patients' arches, confirming that the KöR Desensitizer caused no reduction in whitening effectiveness whatsoever (Figs. 4 and 5).

4) No Need for a Bleaching Light or Laser

As discussed previously, not only are bleaching lights and lasers commonly recognized as being of no benefit for whitening,[48,55-60] but studies have shown a significant increase in whitening sensitivity and sometimes acute pain.[16,17,49,112]

By separating in-office whitening gels into three separate containers (Tri-Barrel) instead of only two containers (Dual Barrel), KöR in-office Dual Activated, Tri-Barrel Hydremide Peroxide (Fig. 6) was

11. Heymann HO. Tooth whitening: Facts and fallacies. Br Dent J. 2005.
112. Kugel G, Ferreira S, Sharma S, Barker ML, Gerlach RW. Clinical trial assessing light enhancement of in-office tooth whitening. J Esthet Restor Dent. 2009;21(5):336-47.
135. Gerlach RW, Barker ML, Rubush ME, Brendemuhl S, Hales B, Magnusson I. Tooth Color on Treated Versus Untreated Arches. The Procter & Gamble Company, Mason, OH, USA, 2University of Florida - Gainesville, USA
136. Ward M, Felix H. A clinical evaluation comparing two H2O2 concentrations used with a light-assisted chairside tooth whitening system. Compend Contin Educ Dent. 2012 Apr;33(4):286-91.
137. Kugel G, Papathanasiou A, Williams AJ 3rd, Anderson C, Ferreira S. Clinical evaluation of chemical and light-activated tooth whitening systems. Compend Contin Educ Dent. 2006 Jan;27(1):54-62.
138. Hein DK, Ploeger BJ, Hartup JK, Wagstaff RS, Palmer TM, Hansen LD. In-office vital tooth bleaching-what do lights add? Compend Contin Educ Dent. 2003 Apr;24(4A):340-52.

continued on page 100

formulated with two distinctly different chemical accelerators, both of which force a rapid breakdown of peroxide to the most effective bleaching factors.

This allows not only very effective whitening, but prevents the formation of substance P within the pulp, greatly reducing the potential of discomfort from in-office whitening.[49]

5) Preventing the Formation of Acidic pH During Whitening

As discussed previously, the breakdown of peroxide to the most effective whitening factors also results in the release of large numbers of hydrogen ions (acid) (Fig. 1).[10,13,16,26-30] With the ability to separate the whitening formula into three separate containers (Tri-Barrel), KöR has been able to add a buffering system to its whitening gels (Fig. 6). The result is the ability to force the most effective bleaching factors from peroxide, yet neutralize the acid as it forms.

This ability keeps the osmolality of the whitening gel very low[16,17] (less potential for sensitivity[16,17,33-36]) as well as avoiding the acid removal of smear plugs during whitening and other detrimental changes to tooth structure.[35,36]

As you may remember, acid is also a chemical stabilizer of whitening gels,[10,14,16,17] so by preventing the acid buildup during whitening, the chemical remains very unstable, and therefore very effective throughout the entire time of application.[14]

KöR Desensitizer also contains sodium fluoride. Sodium fluoride not only may enhance the desensitizing effect,[65,115,116] but most importantly, has been shown to promote remineralization and increased enamel surface micro-hardness after whitening.[139,140] Remineralization may promote the filling of natural surface voids in enamel opened by the oxygenation (cleansing) phase of whitening,[139] which may not only increase enamel surface micro-hardness,[139,140] but result in an even whiter result and less potential for relapse of whitening.

There is currently no effective whitening system that can truthfully claim "no sensitivity," however, with the meticulous scientific approach discussed in this article series, both the incidence and severity of whitening-related sensitivity may be greatly reduced, and in the majority of cases virtually eliminated.

Conclusion

In this four-part article series discussing the science of teeth whitening, you have learned the science of how teeth whitening works, why teeth whitening failures and sensitivity occur, and the effective solutions to predictably achieve the maximum whiteness possible for all of your patients.

You've also learned that predictable and impressive teeth whitening is not simply about slapping some whitening gel on the teeth. There is far more to it than that. The effective solution is not difficult – it's not costly – it is simply precise, detail-oriented and based on scientific principles.

To receive more information about the KöR Whitening System, call (866) 763-7753. ■

35. *Sun L, Liang S, Sa Y, Wang Z, Ma X, Jiang T, Wang Y. Surface alteration of human tooth enamel subjected to acidic and neutral 30% hydrogen peroxide. J Dent. 2011 Oct;39(10):686-92. Epub 2011 Aug 9.*
36. *Carrasco-Guerisoli LD, Schiavoni RJ, Barroso JM, Guerisoli DM, Pécora JD, Fröner IC. Effect of different bleaching systems on the ultrastructure of bovine dentin. (Dental Traumatology) Dent Traumatol. 2009 Apr;25(2):176-80*
65. *Matis B, Gaiao, U, Blackman D, Schultz A, Eckert G. In Vivo Degradation of Bleaching Gel Used in Whitening Teeth. J Am Dent Assoc. 1999; 130(2).*
115. *Docimo R, Montesani L, Maturo P, Costacurta M, Bartolino M, Zhang YP, DeVizio W, Delgado E, Cummins D, Dibart S, Mateo LR. Comparing the efficacy in reducing dentin hypersensitivity of a new toothpaste containing 8.0% arginine, calcium carbonate, and 1450 ppm fluoride to a benchmark commercial desensitizing toothpaste containing 2% potassium ion: an eight-week clinical study in Rome, Italy. J Clin Dent. 2009;20(4):137-43.*
116. *Nathoo S, Delgado E, Zhang YP, DeVizio W, Cummins D, Mateo LR. Comparing the efficacy in providing instant relief of dentin hypersensitivity of a new toothpaste containing 8.0% arginine, calcium carbonate, and 1450 ppm fluoride relative to a benchmark desensitizing toothpaste containing 2% potassium ion and 1450 ppm fluoride, and to a control toothpaste with 1450 ppm fluoride: a three-day clinical study in New Jersey, USA. J Clin Dent. 2009;20(4):123-30.*
139. *Leandro GA, Attia ML, Cavalli V, do Rego MA, Liporoni PC. Effects of 10% carbamide peroxide treatment and sodium fluoride therapies on human enamel surface microhardness. Gen Dent. 2008 May;56(3):274-7.*
140. *Faraoni-Romano JJ, Da Silveira AG, Turssi CP, Serra MC. Bleaching agents with varying concentrations of carbamide and/or hydrogen peroxides: effect on dental microhardness and roughness. J Esthet Restor Dent. 2008;20(6):395-402; discussion 403-4.*

Author's Bio

Dr. Rod Kurthy practices in Mission Viejo, California. He graduated with highest honors from Fairleigh Dickinson University School of Dentistry in 1978, and completed a GP residency at Newark Beth Israel Medical Center.

Dr. Kurthy's 35 years of research and development include laser and surgical periodontal bone regeneration; endodontic surgery, including bone regeneration and repair of resorptive lesions; teeth whitening; teeth sensitivity; and development of several cosmetic techniques and impression techniques, to name a few. His first participation in periodontal research was in 1976, and teeth whitening in 1977.

He is an international lecturer and author of five popular clinical and dental marketing books. He is the recipient of awards and accolades including the Mosby Scholarship Award; FDU Prosthodontics and Pediatric Dentistry Awards; the Omicron Kappa Upsilon Gold Key Award; a commendation from the Chief Attorney of the United States Department of Defense for his role in supporting patients' rights in disputes with insurance carriers; and in March, 2005, he was selected as the most respected member of Dentaltown.com by more than 60,000 of his peers.