Ozone Treatment of Dental Caries

A Paradigm Shift in Conservative Dentistry

by George Freedman DDS, BSc Fay Goldstep DDS, BSc

Fig. 1

Throughout the history of dentistry, the profession has concerned itself with the evermore efficient amputation of diseased dental tissues. Cavity preparation, guided by the limitations of restorative materials, has been accomplished with increasingly faster and more efficient burs. The negative corollary of these more effective burs has been the inadvertent, indiscriminate removal of both healthy and decayed tooth structures. While practitioners have increasingly adopted minmally invasive techniques, the limitations of diagnostic, preparation, disinfection, and suitable tooth-mimicking restorative materials have hampered progress. The dental professionals' goal is, and should be, Conservative Dentistry, the treatment process whereby healthy tooth tissue is not removed during the preparation process (natural enamel and dentin are still far better than any restorative materials available). An even more radical approach is the retention of previously diseased tooth structure, its remineralization, and its restoration to normal form and function; this healing and repair of the natural dentition must be the focus of dental treatment. The patients' objectives are somewhat simpler. Their major barriers to seeking dental care consist of a generalized fear of pain, and a specific aversion to intraoral injections. (Even in those countries where dentists, technologies,

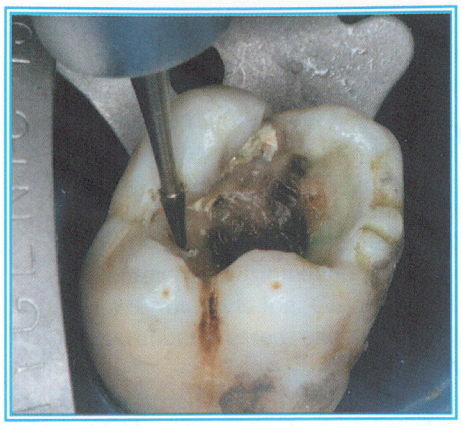

Fig. 2

Fig. 3

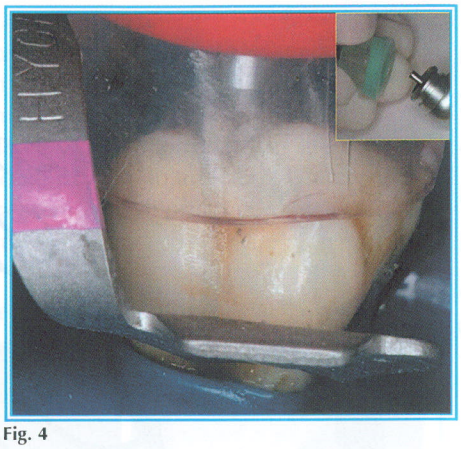

Fig. 4

Aero-therapeutic restorative dentistry: clinical technique

Diagnosis and treatment planning

1. The decayed area is identified visually, tactilely, by Diagnodent, and/or radiographically. (Fig 1)

2. The patient is informed about the availability of the aero-therapeutic technique, and that no local anesthesia is suggested (what is always available upon request).

Minimally invasive preparation

3. The access through the enamel is developed with a depth-limiting Fissurotomy bur (SSWhite Burs Inc., Lakewood NJ). (Fig 2)

4. The access opening must be large enough to accommodate the insertion of the appropriate SmartPrep instrument (SSWhite Burs Inc., Lakewood NJ), which is used to diagnose and selectively remove soft dentinal decay. (Fig 3) There must be enough visual access to determine if any soft decay has been left in the cavity.

HealOzone procedure

5. A disposable sterile cup on the HealOzone handpiece (KaVo/SciCan, Toronto ON) is used to form a seal around the prepared tooth. (Fig 4) Once the seal is patent (and only then), ozone is delivered into the lesion, and refreshed 300 times per second, for 40 seconds.

6. HealOzone remineralizing solution, containing xylitol, fluoride, calcium, phosphate and zinc, is applied directly to the demineralized dentinal surface. (Fig 5)

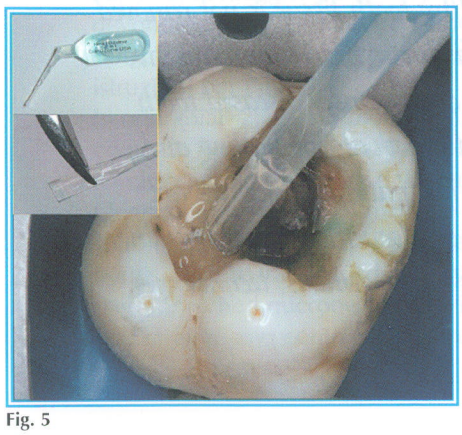

Fig. 5

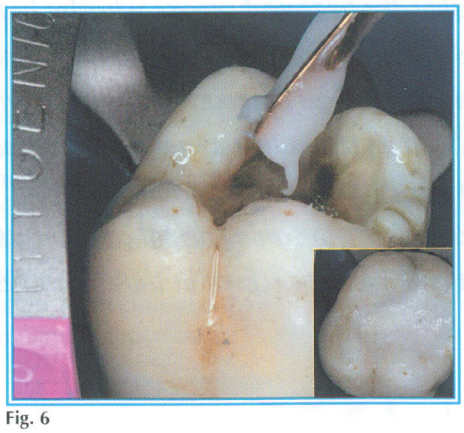

Fig. 6

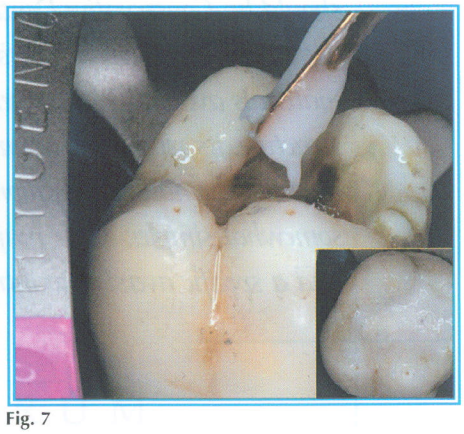

Fig. 7


Fig. 8

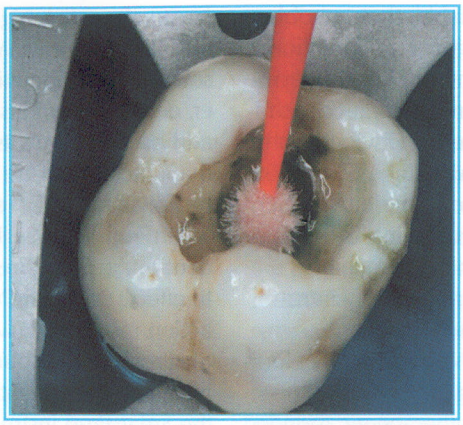
Fig. 9

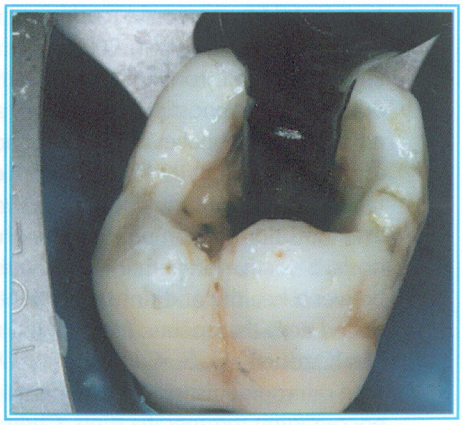
Fig. 10

Remineralizing provisional procedure

7. A glass ionomer cement is placed into the preparation as a mediumterm provisional restoration. (Fig 6) The glass ionomer cement is left in the cavity preparation up to a year or longer for the purpose of remineralizing the remaining tooth structures. This process can also be established with remineralizing oral rinses and toothpastes.

Definitive restoration procedure

8. Any remaining glass ionomer cement is removed by excavation or a very slow round carbide bur, (Fig 7) usually without local anesthesia. If required, normal matrix isolation and wedging can be used. The hardened dentinal surface is rinsed, and the excess water is removed (iBond is not moisture sensitive). (Fig 8)

9. One-bottle, one-step 7th generation adhesive iBond (Heraeus Kulzer Inc., Armonk NY) is applied to the preparation (3 X 10 seconds), agitated on the surface, air-dried, and then light cured for 10 seconds. (Fig 9) (There are no separate etching, conditioning, priming, or desensitizing steps.)

10. A shade-matched composite, Venus (Heraeus Kulzer Inc., Armonk NY) is applied to the cured adhesive. (Fig 10) It is a color-adaptive microhybrid composite resin that is available in a variety of shades, along with a cookbook-style 2- component shade guide.

11. The surface composite layers are molded to approximate natural contours with the anatomically designed "duckhead" instrument (Hu-Friedy Inc., Chicago IL) to minimize the time and effort required for final polishing after polymerization. (Fig 11)

12. The finished surface is painted with Seal-n-Shine (Pulpdent Corp., Watertown MA), (Fig 12) a resin sealing material that polymerizes hard, without the formation of an oxygen inhibited layer, leading a hard, smooth, transparent and resilient restorative surface. (Fig 13)

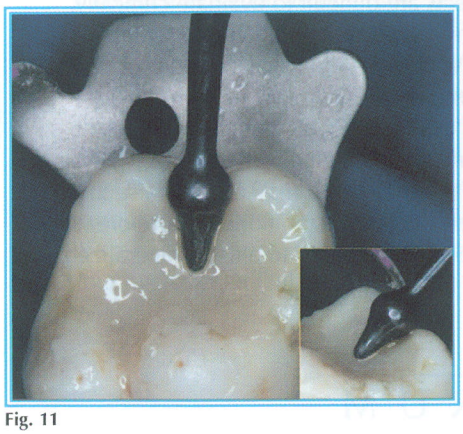
Fig. 11

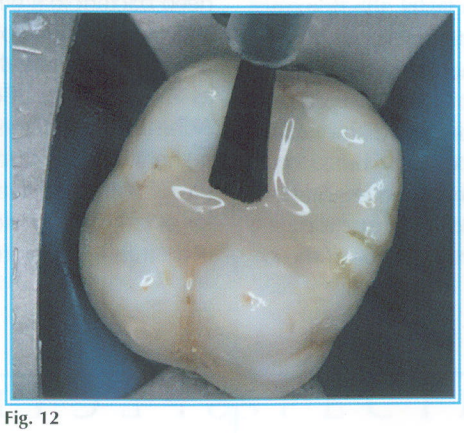
Fig. 12

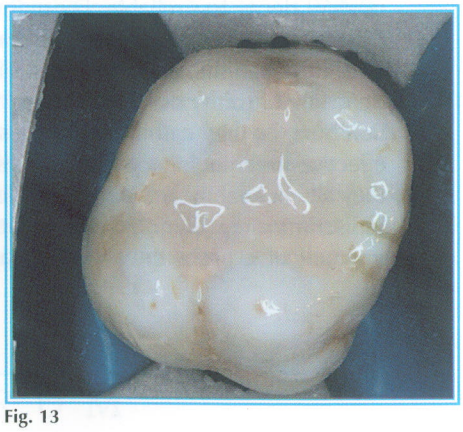
Fig. 13

and dental insurance are readily available, these phobias are responsible for up to 50% of the general population tending to avoid routine dental treatment.) Recent developments in diagnostic, preparation, and restorative technologies serve to alleviate these concerns. Devices such as the Diagnodent (KaVo America Corp., Lake Zurich IL),digital radiography (Sirona USA Inc., Charlotte NC), and transillumination provide non-threatening caries diagnosis. Selective preparation instruments differentiate between healthy and unhealthy dentin. Recently introduced aero-therapeutic techniques such as HealOzone(KaVo/SciCan, Toronto ON) successfully eliminate microorganisms in the remaining tooth structure, encouraging remineralization. Chemotherapeutic (bonded resin, etc.) restorations offer a stronger and more predictable restor tive interface. The combined use of these technologies makes dentistry more accessible, more acceptable, and will ultimately lead to a greatly increased utilization of dental services worldwide.

The preparation surface: differential diagnosis of decay

At the decay interface inside the cavity preparation, there are three types of dental tissues: soft (decayed dentin and enamel), leathery (infected dentin that is either demineralizing or remineralizing), and hard (healthy dentin and enamel).[1,2] Very soft tissues are extensively demineralized, and may not be remineralizable with current technologies.[3] These lesions must be removed from the cavity. The leathery tissues, undergoing demineralization or remineralization, are likely to have a more uniform distribution of minerals.[3] The direction of this process is of less concern than the tissues' potential for mineral recharging; recent developments indicate quite clearly that these leathery lesions, given the proper ionic compartment, can remineralize and harden.[4-6] Hard dentin and enamel are usually healthy (although they may harbor live bacteria), and should be left intact. The primary task is the differential diagnosis of those tooth structures that should be removed, and those to be left intact.

Current higher-speed radiographic films make visual diagnosis of decay less reliable. For many years, the primary diagnostic tool to differentiate hard and soft tooth structures has been the tactile explorer. There is extensive evidence that healthy dentin is harder.[7,8] Traditional preparation burs, be they carbide, stainless steel, or diamond, are effective in removing tooth structures quickly, but they attack healthy and unhealthy dentin and enamel indiscriminately. During the preparation process, it is impractical to probe the entire prepared surface of the cavity after each high or low speed cut. SmartPrep polymer instruments (SSWhite, Lakewood, NJ) are the first selective dental cutting tools designed to remove the softer, decayed portions of dentin while leaving the healthier and harder segments intact. The SmartPrep polymer is manufactured to be harder than decay and yet softer than healthy dentin. On encountering soft, decayed tissue, the SmartPrep abrades it; when it touches harder, healthier dentin, the SmartPrep polymer itself is selectively abraded. In effect, the SmartPrep instrument is a selflimiting, dual-action instrument, which provides an on-site differential diagnosis of the soundness of dentin, and then immediately removes any dentin that fails the hardness test. Since the SmartPrep instrument is not hard enough to open healthy dentinal tubules,[9] it can routinely be used without local anesthetic, with total patient comfort.[10-13] SmartPrep preparation technique recommends retaining discolored hardened dentin[14,15] that is in fact bondable,[16] and will not compromise the tooth-restoration complex. Previously, the concern of whether any live bacteria remained in the healthy or remineralized dentin was addressed by the use of an acid etch during the adhesive process. The introduction of Aero-therapeutic ozone therapy to completely eliminate bacteria at and below the preparation surface enhances the predictability of these new techniques.

The tooth-restorative interface: caries control and adhesion

The dental profession has long assumed that once tooth structure has decayed, it can never again be functional or healthy. This myth has been repudiated by research indicating that clinical caries can be reversed by aero-therapeutic treatment.[17] Thus, earlier, more invasive preparation concepts that require the elimination of decay, suspected decay, and healthy dentin beyond the suspected zone of decay (just to be on the safe side), are outdated. These aggressive approaches certainly result in the unnecessary removal of healthy tooth structure, without any guarantee that microorganisms are not lurking immediately beyond the preparation surface. Acid etching destroys surface bacteria, and penetrates enamel and dentin, but its deep bactericidal effects are difficult to evaluate clinically. Even so, the very common separate acid etching step has been eliminated with the latest adhesive agents such as 7th generation iBond (Heraeus Kulzer, Armonk NY).[18] Adhesive parameters assume fully mineralized dentin. A higher organic content in demineralized dentin may play havoc with adhesive properties and may compromise the longterm marginal seal of these restorations.[17] Therefore, it is desirable to restore affected dentin to a fully mineralized

state prior to a permanent restorative procedure. Research indicates that carious and cavitation processes of the dentin can be arrested by aero-therapeutic treatment, and these tissues can be remineralized to a bondable state.[19-21] Further, once these lesions are remineralized, they tend to be less susceptible to active caries in the future.[22-24] (This may be the most important long-term benefit of aero-therapeutic procedures.) Once dentin has been restored to its maximum adhesive capacity, a permanent direct or indirect restoration can be placed with full long-term confidence.

The tooth-restorative interface: caries reversal and remineralization

While adhesive dentistry has been researched extensively, and is well established, clinical remineralization has remained elusive. There are three major factors that have conspired against dentin remineralization:

1. the presence of aciduric microorganisms
2. the ongoing activities of aciduric microorganisms
3. the willingness (and ability) of patients to control their oral environments

Over the years, practitioners have achieved limited success in modifying the daily behavior of the patient (tooth-brushing, flossing, etc.). The routines that are required for continued oral health are not immediate in their effect, and are easily omitted or forgotten. Professionally, it may be easier to control oral biofilm through alternative pharmaceutical management strategies such as ozone therapy.[22-24] Human saliva is actually an excellent remineralizing medium; it contains buffering minerals such as calcium, phosphate, and fluoride which can promote remineralization[25,25] in the absence of bacteria. Acid-producing microorganisms are associated with plaque and caries promoting conditions.[27,28] Therefore, it may be readily inferred that bacterial control can limit the extent and the destruction of dental caries. Remineralization has been observed to occur in the absence of aciduric microorganisms were there is a readily available source of mineral ions such as saliva, an oral rinse, or restorative material.[19-21] Ozone is a proven antimicrobial agent that has been used extensively in medicine for many years. Ozone so powerful that a 10 second application eliminates more than 99% of the microorganisms found in dental biofilm.[23,24] Ozone occurs naturally when molecular oxygen (O2) is photodissociated into activated ions (O-) that in turn combine with other oxygen molecules (O2) to form transient radical anions (O3). Ozone eventually decomposes to a hydroxyl radical which is a powerful oxidant. Ozone oxidizes biomolecules such as cysteine, methionine, and histidine, disrupting microbial cell structures and metabolism within seconds,[29,30] leading to immediate cell lysis. The virtually instantaneous bactericidal activity is central to effective dental ozone therapy. Considering that a 10 to 20 second application of ozone effectively destroys oral microbes, the recommended 40 second HealOzone treatment time should be totally effective1 in the destruction of the aciduric and acidogenic microorganisms, and their protective biofilm environment. In this altered micro-environment, the remineralization of tooth structures is readily achieved.[25,26] At 18 months, 100% caries reversal and remineralization has been observed with root caries affected teeth.

Since regular remineralization rinsing, for months or years at a time, requires a level of patient motivation that is rather rare, another method to precipitate ion release at the preparation surface is desirable. Glass ionomer cements, safe and reliable ion sources, have been available to the dental profession more than 30 years. A GIC that is placed in direct contact with the demineralized dentinal surface will be an excellent source of ions that does not depend on patient compliance. GI cements wear much more quickly than micro-hybrid composites, and their surfaces tend to stain and pit. Thus the use of GI cements as definitive restorations, particularly on occlusal surfaces, is contraindicated.

Micro-hybrid composites, on the other hand, rival and often excel amalgams, and in many parts of the world composites are the accepted restorative standard; they are functional long-term dental restorations, and can be made quite aesthetic. Most composites do not, however, release ions that can recharge the underlying dentinal surface. Clinically, the patient is best served by utilizing these two classes of materials sequentially. The glass ionomer cement is placed first (as a provisional/temporary restoration) to effectively remineralize the dentinal surfaces once the soft decay has been selectively removed. After a 12 to 18 month remineralizing period, the provisional GI cements is removed mechanically, revealing an ionically recharged, hardened, and bondable dentinal surface. The resulting cavity can now berestored to full function and form with the latest adhesive restorative materials. While the restorative treatment has now evolved to two appointments, separated by a year or more of dentinal remineralization, the conservation and subsequent remineralization questionable dentin are well worth the extra time. Patients appreciate that the clinical steps described below can most often be completed without requiring local anesthesia; this permits large segments of the population that pointedly avoids dental treatment to seek care without fear or discomfort.

As an additional benefit, it has become clear that once lesions are ozone treated and have remineralized, they are very unlikely to be actively carious again.[23,24] This feature, for the very first time, provides the dental profession with the means of not only eliminating caries, but of controlling the cariogenic process itself. As the use of aero-therapeutic dental procedures expands, this technique is likely to improve voluntary patient access to dental care and to have a dramatic effect on dental health and its longterm maintenance.

The procedure illustrated in this article is a very conservative approach to preparation and restoration that does not require local anesthesia at any step. The dentist can be certain that all of the necessary caries (but only the soft dentin) was removed. The questionable and/or soft dentin has been retained and remineralized for long-term functional dental health. The restoration is occlusally functional, and aesthetically acceptable. The combined technologies of aero-therapeutic caries control, remineralizing restorative materials, conservative access instruments, and aesthetic and functional restorative materials provide the truly conservative techniques that return dentistry to its original mission as a healing art.

References

1. Lynch E. The measurement of root caries for research purposes. J Dent Res 1986; 65: 510.

2. ten Cate JM, van Amerongen JP. Caries diagnosis, conventional methods. Proceedings of the First Annual Indiana Conference, Indianapolis. Indiana University School of Dentistry (ISBN 0-9655149), 1996, 27-37.

3. Nyvad B, Fejerskov O. Scanning electron microscopy of early microbial colonization of human enamel and root surfaces in vivo. Scand J Dent Res 1987; 95: 287-296.

4. Hellyer PH, Beighton D, Heath MR, et al. Root caries in older people attending a general dental practice in East Sussex. Br Dent J 1990; 169: 201-206.

5. Beighton D, Lynch E, Heath MR. A microbiological study of primary root caries lesions with different treatment needs. J Dent Res 1993;73: 623-629.

6. Lynch E. The diagnosis and management of primary root caries. PhD. thesis, University of London, 1994.

7. Hosoya Y, Marshall SJ, Watanabc LG, Marshell GW, Microhardness of carious deciduous dentin. Oper Dent 2000;25:81-89.

8. Meredith N, Sherriff DJ, Swanson SAV. Measurment of the microhardness and Youngs's modulus of human enamel and dentin using an indentation technique. Arch Oral Biol 1996;41:539-545.

9. Yamada T, Nakamura K, Iwaku M, Fusayama T. The extent of the odontoblast process in normal and carious human dentin. J Dent Res 1983;62:798-802.

10. Fusayama T. A simple pain-free adhesive restorative system by minimal reduction and total etching. Tokyo: Ishiyaku EuroAmerica, Inc. 1993:2.

11. Fusayama T. A simple pain-free adhesive restorative system by minimal reduction and total etching. Tokyo: Ishiyaku EuroAmerica, Inc. 1993:56.

12. Ericson D, Zimmerman M, Raber H, Gotrick B, Bornstein R. Clinical evaluation of efficancy and safety of a new method for chemo-mechanical removal of caries. Caries Res 1999;33:171-177.

13. Anusavice KJ, Kincheloe JE. Compasion of pain associated with mechanical and chemomechanical removal of caries. J Don't Res 1987;66:1680-1683.

14. Fusayama T, Okuse K, Hosada H. Relationship between hardness, discoloration and microbial invasion in carious dentin. J Dent Res 1966;45:1033-1046.

15. Fusayama T, Okuse K, Hosada H. Relationship between hardness, discoloration and microbial invasion in carious dentin. J Dent Res 1966;45:1033-1046.

16. N.R.F.A. Silva, V.P. Thompson. I.A.D.R.; San Anton 0227; 2003.

17. Holmes J. Clinical Reversal of Root Caries Using Ozone, Double Blind, Randomised, Controlled 19-Month Trial. Prepub.

18. Freedman G, Leinfelder K. Seventh-Generation Adhesive Systems Dentistry Today November 2002 21:11 106-111

19. Baysan A, Lynch E. Management of primary root caries with a high fluoride dentifrice. Tissue Preservation and Caries Treatment. Quintessence Book 2001, Chapter 2, 37-48.

20. Lynch E, Baysan A. Reversal of primary root caries using a dentifrice with a high fluoride content. Caries Res. 2001; 35::60-64.

21. Baysan A, Lynch E, Ellwood R et al. Reversal of primary root caries using dentifrices containing 5,000 and 1,100 ppm fluoride. Caries Res. 2001; 35: 41-46.

22. Lynch E, Beighton D: A comparison of primary root caries lesions classified according to colour. Caries Res 1994; 28: 233-239.

23. Baysan A, Lynch E, Grootveld M. The use of ozone for the management of primary root carious lesions. Tissue Preservation and Caries Treatment. Quintessence Book 2001, Chapter 3, 49-67.

24. Baysan A, Lynch E Effect of ozone on the oral microbiota and clinical severity of primary root caries Am J Dent, 2004, Accepted for publication

25. Silwood CJ, Lynch E, Claxson AW, et al. 1H NMR investigations of the molecular nature of low-molecular-mass calcium ions in biofluids. J Biol Inorg Chem. 2002; 7: 46-57.

26. Silwood CL, Grootveld M, Lynch E. 1H and 13C NMR spectroscopic analysis of human saliva. J Dent Res. 2002; 81: 422-427.

27. Fure S. Five-year incidence of caries, salivary and microbial conditions in 60-, 70- and 80-year-old Swedish individuals. Caries Res 1998; 32: 166-174.

28. Beighton D, Lynch E. Comparison of selected microflora of plaque and underlying carious dentine associated with primary root caries lesions. Caries Res. 1995; 29::154-158

29. Bocci V. Ozone as a bioregulator. Pharmacology and toxicology of ozonetherapy today. J Biol Regul Homeost Agents 1996; 10: 31-53

30. Bocci V. Biological and clinical effects of ozone. Has ozone therapy a future in medicine? Br J Biomed Sci 1999; 56: 270-279