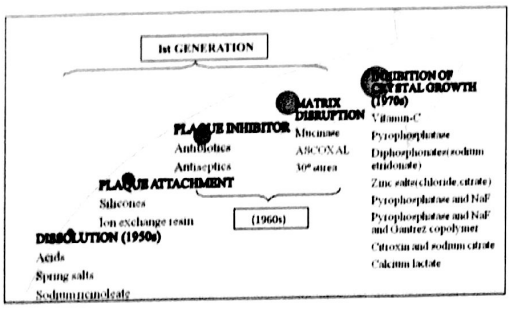
effect. The content of pyrophosphate in dentifrices is derived from pyrophosphate salts of sodium and/or potassium.



Current anticalculus agents in detail

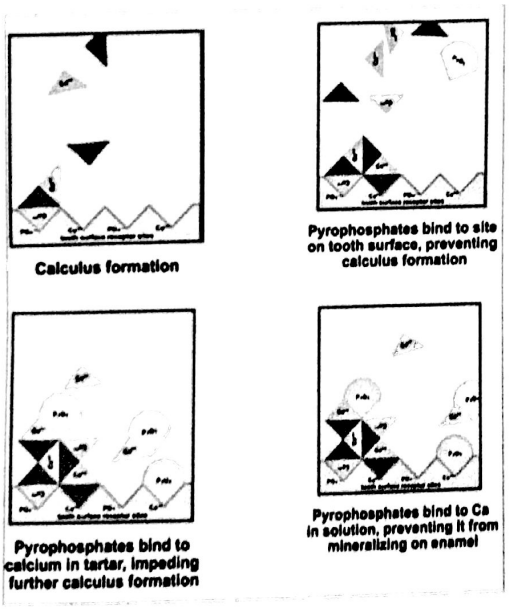


Fig. 4. Animation of anticalculus activity of pyrophosphates and other mineralization inhibitor molecules to control the mineral formation within dental plaque.

(From: White D J, Gerlach R W. Anticalculus Effects of a Novel, Dual-Phase Polypyrophosphate Dentifrice: ChemicalBasis, Mechanism, and Clinical Response. J Contemp Dent Pract 2000;(1)4: 001-019.)

Pyrophosphates with NaF: Preliminary studies indicated that pyrophosphates were rapidly broken down in the oral cavity by bacterial and salivary pyrophosphatase enzymes. Hence, in the 1980s, formulations were created using high concentrations of pyrophosphates that could be combined with sodium fluoride to both retain anti-caries potency (Lu et al, 1985; Triol etal, 1988; Koch etal, 1990) and reduce tartar build-up (not preformed tartar) and indeed, the concentration of sodium fluoride was high enough to serve as an anti-enzyme and help inhibit the limiting pyrophosphatases in the mouth. (Mellberg et al. (1987)

Pyrophosphates with copolymer: Dealing with hydrolysis and inactivation of pyrophosphate in a dentrifice in the oral cavity by the salivary and plaque enzymes, Gaffar et al (1987) pointed out that NaF mitigates the hydrolysis of pyrophosphates by acid phosphatase and pyrophosphatases in saliva and plaque, but had no effect on the activity of alkaline phosphatase. They used a 1% copolymer of polyvinylmethyl ether and maleic acid anhydride (Gantrez•) which inhibits alkaline phosphatase invitro and may reduce the hydrolysis of pyrophosphate in vivo and may act as an anticalculus agent (Gaffar and Esposito, 1986). The incorporation of Gantrez• into a dentifrice with pyrophosphates and fluoride led to a number of clinical trials to determine the optimum formulation for anticalculus effect.

A two phase, six month, double blind clinical study was conducted to compare the effect on supragingival calculus deposits of a dentifrice containing 1.30% soluble pyrophosphate (from 2.0% tetrasodium pyrophosphate) with and without the presence of 1.50% of a copolymer of methoxyethylene and maleic acid (Volpe et al 1990). It was concluded that the presence of the copolymer in the soluble pyrophosphate dentifrice was essential for obtaining a statistically significant anticalculus effect of 29.54%, as compared to the placebo dentifrice.

|| Zinc Citrate

Salts of zinc have been incorporated into oral hygiene preparations for many years. The use of zinc as an antiplaque agent has been reviewed by Adams and Addy (1994). Zinc has also been known as an inhibitor of crystal growth of calcium phosphate and has been in use as an anticalculus agent for many years (reviews by Gilbert et al., 1989;Stookey et al, 1989).

A beneficial anti calculus effect for zinc was found by

Kazmierczak et al (1990), who compared a 2% zinc citrate dentifrice with a pyrophosphate preparation and a paste with no anticalculus ingredient. Brushing using zinc citrate with pyrophosphate dentifrice resulted in a statistically significant reduction of 21% over the control product.

The evidence from such trials would seem to indicate that, in order to be effective as an anticalculus agent in a dentifrice, zinc citrate concentrations of at least 2% are required, when it is used as the sole anticalculus agent, and its benefits take some six months to become evident. However, when 0.5%zinc citrate is combined with 0.2% triclosan, 50% reduction in supragingival calculus have been reported. Zinc citrate does not interfere with the anticaries effects of fluoride in a dentifrice (Stephen et al., 1988), and anticalculus toothpastes containing zinc usually include fluoride in their formulation.

A systematic review of the effectiveness of anticalculus dentifrices identified 32 reports containing comparisons of one or more active agents with a placebo dentifrice and calculus measured using the Volpe-Manhold Index (VMI) (Netuveli G.S. 2004). Meta-analysis of all the studies with 6-month follow-up gave an effect size of -1.1 and for 12-month follow-up the effect size was -13. Thus, it was concluded that anticalculus dentifrices containing pyrophosphates, zinc compounds and/or co-polymers were effective in significantly reducing calculus scores (VMI).

|| Triclosan

Although it has been shown that micro-organisms are not essential for the development of dental calculus, it has been suggested that they may contribute to calculus formation. Consequently, there have been many trials of antimicrobials as anticalculus agents (reviewed by Stookey et al., 1989).

Triclosan is a broad-spectrum antibacterial agent, widely used for skin infections. It is the non-proprietary name of the compound 2,4,4_-trichloro-2_-hydroxydiphenyl ether, and was originally used as an adjunct to zinc citrate as an antiplaque agent (Saxton, 1986). The earliest report of Triclosan as an anticalculus agent seems to be that of Svatun et al. in 1989 in a one-year study of gingival health, in which plaque levels, bleeding points, and calculus were reduced in the group using a Triclosan/zinc citrate/fluoride dentifrice. It has been demonstrated that there is a greater uptake of triclosan to enamel and buccal epithelial cells from the use of a fluoride dentifrice containing triclosan and the PVM/MA copolymer than from a dentifrice containing triclosan alone. Volpe et al. (1993) have reviewed three long-term clinical trials of a 0.3% Triclosan and 2.0% Gantrez® dentifrice in efficacy studies to reduce plaque, gingivitis, calculus, and caries. They found reductions of calculus formation of 23% and 35%, respectively, while Lobene et al. (1990, 1991) found reductions of 26% after three months and 36% after six months compared with the placebo controls.

The use of Triclosan with 5% pyrophosphate would appear to be a powerful combination, one agent inhibiting crystallization and the other reducing the micro-organisms that contribute to calculus growth. A double-blind parallel-group clinical study (Fairbrother et al,1997) supports the clinical effectiveness of PPi/TCS and Zn/TCS dentifrices for the reduction of supragingival dental calculus formation following a dental prophylaxis. Another double-blind clinical study, to compare the efficacy of a dentifrice containing 0.3% triclosan/2.0%(PVM/MA) copolymer/ 0.243% sodium fluoride in a 17% dual silica base to that of a commercially available dentifrice containing 0.243% sodium fluoride in a silica base with respect to the reduction of supragingival calculus formation proved that the Test Dentifrice group exhibited 34.8% less supragingival calculus formation than the Control Dentifrice group (Schiff et al 2008).

Thus, the anticalculus literature has been dominated by the pyrophosphates, zinc citrate, Triclosan, and the copolymer Gantrez®, but there have been reports of other interesting compounds too, in recent years.

|| Other Agents

Calcium lactate has been used by Schaeken and Van der Hoeven (1990, 1993) in a trial of anticalculus efficacy. Using a modification of a plaque-scoring index, they showed that calcium lactate significantly reduced supragingival calculus formation over a three-month period. The mechanism of calculus reduction is not known. Recently, sodium bicarbonate has been introduced into toothpastes as anticalculus agent.

There are other anti-tartar formulations that have not applied for nor received the ADA Seal. One such

product, a toothpaste containing Citroxain -- a mixture of the enzyme papain, sodium citrate and alumina -- has some supporting published data"117% greater calculus reduction...than the control" but only 19% greater reduction in plaque (Lyon et aL, 1991) and is marketed primarily as a whitening toothpaste.

To conclude, we have many choices for anti-calculus strategy, but it has been developed and reformed till date only as a home-care adjunct to professional mechanical plaque control which still remains the gold standard to maintain a healthy periodontium and a healthy mouth.

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