RINSING AWAY DECAY

While new inroads in chemical dentistry aren't likely to make the dentist's drill obsolete, they may reduce the need for drilling and even more serious dental work

By JANET RALOFF

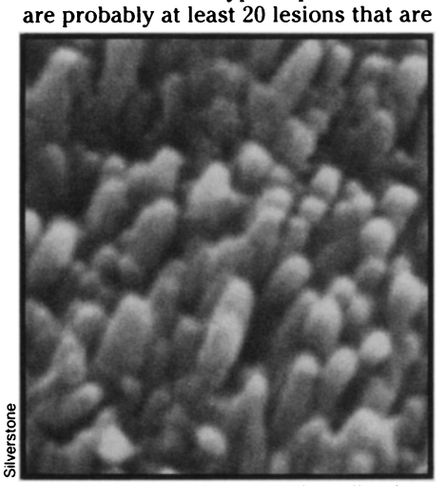
It's the ultimate in painless dentistry—some might even say "natural" dentistry. By harnessing chemical reactions that involve fluoride, calcium and phosphate, researchers are developing new weapons for the war on cavities. A major focus is the development of mouth rinses that work as synthetic "supersalivas." Generally envisioned as a home-based addition to a regular brushing and flossing regimen, they're being aimed not only at fighting decay but also at strengthening teeth and even repairing developing cavities.

One of the pioneering treatments, based on such a mouth rinse, has been used for more than 10 years in the experimental management of people with otherwise rampant, uncontrollable tooth decay. Other treatments will undergo clinical trials in the next few years. None is expected to put the dentist out of work. In fact, as an adjunct to the mechanical dentistry best symbolized by the pick and drill, these treatments promise to help preserve much of the dentist's handiwork—from fillings to caps and crowns—that might otherwise be lost as subsequent decay eroded the teeth onto which these were anchored.

In the mouth, a process of demineralizing and remineralizing—a dissolving and reforming of tooth mineral—occurs continually at the surface of teeth. Plaque-forming bacteria, which thrive on the fermentable carbohydrates in food, create weak acids (SN: 3/29/86, p. 203). It's these acids that demineralize teeth. Saliva contains the constituents needed to remineralize them again. Carious lesions, or caries, form when demineralization exceeds remineralization.

In its first stages, a carious lesion does not contain an actual "cavity"; the tooth mineral just becomes more porous and "spongy" as swiss-cheese-like holes begin to form within it. When perforations become too numerous and too large, a hole or cavity forms, or the weakened tooth breaks.

"We have shown over 20 years that wherever one side of a tooth touches another, there's a [carious] lesion," says Leon Silverstone, director of the University of Colorado's Oral Sciences Research Center in Denver. Crowded teeth, therefore, always harbor decay. "In fact," he says, "by the time a lesion is clinically detectable, it may have existed just below the tooth surface for about three years." Using microscopy, he explains, "we have shown that in the typical person there are probably at least 20 lesions that are small but cannot be seen by our best available diagnostic techniques" — like visual inspection or dental X-rays.



Silverstone

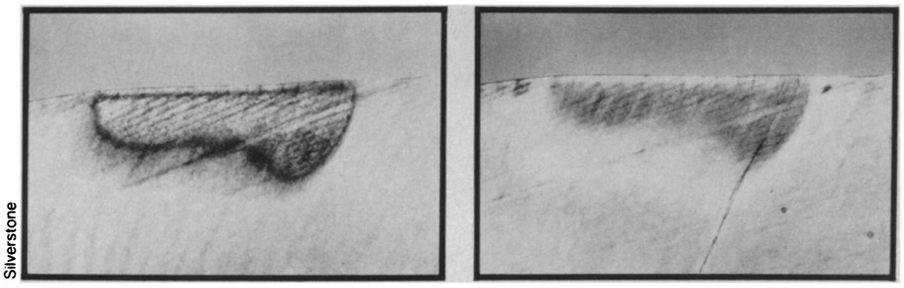
When tooth crystals are remineralized, they often become larger — and therefore stronger — than the originals. Enamel crystals shown in this scanning electron micrograph have been remineralized from 10-30 microns in diameter to about 100 microns.

Such findings have convinced Silverstone that dental researchers should give up focusing on the impossible: preventing lesions. He says, "We must instead concentrate on stopping them from growing" into true cavities.

An approach being taken by his lab and several others is to create a mouth rinse that outperforms saliva, the body's natural remineralizer. The "calcifying fluids" Silverstone and his colleagues are developing contain a solution of calcium and phosphate, together with a small quantity of fluoride. Calcium and phosphate are the remineralizing constituents of saliva. Fluoride serves as a catalyst to speed the precipitation of calcium phosphate — in the form of a hydroxy apatite — onto or into teeth.

But that's not fluoride's only role. It is able to inhibit the activity of some bacterial enzymes and their acid-producing processes, and at extremely high concentrations it can also kill some plaque bacteria. Even more important, it tends to become incorporated into the apatite (as a fluoridated hydroxy apatite, or "fluorapatite"), creating a mineral that is actually less dissolvable by acids (SN: 3/8/86, p. 150). And, Silverstone says, because the remineralized fluoridated-apatite crystal will be larger than the crystal it replaces, it will have a smaller surface-to-volume ratio. With a smaller exposed surface, acid erosion — or dissolution — becomes a more lengthy process.

In designing a superior remineralizing solution, Silverstone says, the real trick is to tailor its chemistry so that it depos-



Silverstone

Left: Artificially created carious lesion in human enamel, concealed by a 20-micron-thick cover, viewed with polarizing microscope. Right: Ten 6-minute surface exposures to remineralizing fluids have reduced porosity, reduced the lesion area by 86 percent and increased the depth of surface cover by 30 microns.

its new apatite crystals where you need them. And that may not be on the tooth surface.

The acid attack that initiates a carious lesion begins the process of decay by dissolving apatite crystals from a tooth surface. Silverstone's research has shown that within a few hours a new layer of hydroxy apatite crystals will form over the initial surface attack. This cover repairs only some of the decay; the rest is buried. Over time, the buried decay will grow as more and more mineral is lost from this "white spot lesion." But its growth is invisible to the dentist, Silverstone says, because the actual tooth surface is hard and apparently healthy. "This is also why it's so difficult to stop a very early cavity," Silverstone points out. "It's covered by a solid, intact surface."

But by varying the relative proportions of calcium to phosphate in the remineralizing fluid, he is learning how to target where new apatite is deposited. "When you have high calcium, you remineralize the outer surface of a tooth," he says. "As you start dropping the calcium, you begin remineralizing inside the tooth." Based on these findings, he's already developed a series of calcifying fluids that he says "are very effective at remineralizing lesions."

By using them to fill in a lesion's swiss-cheese-like holes, people should be able to repair caries naturally, he says, before the decay develops into a full-fledged cavity. Silverstone suspects that these fluids ultimately will be marketed as mouth rinses in a range of formulations, each designed to tackle decay from a different cause or in a different type of tissue – for example, in tooth enamel, or in root tissue. Similar work is under way at the University of Iowa's Dows Institute in Iowa City.

The remineralizing rinse being developed at the University of Rochester (N.Y.) contains, in addition to the standard calcium, phosphate and fluoride, several additives to enhance the transport of the remineralizing chemicals through the enamel, which acts as a molecular sieve. One of the additives, strontium, reduces the solubility of apatite and tooth enamel, particularly when delivered in conjunction with fluoride, says John Featherstone, who chairs the oral biology department at the university's Eastman Dental Center. And tartrate, his studies indicate, enhances the transport of calcium through the enamel to buried carious lesions.

In 14-day tests, he reports, a rinse with these additives rehardened the deep-seated carious lesions Featherstone and his colleagues had initiated in human tooth enamel. In one preliminary test of its ability to work under real-world conditions, the researchers embedded tiny test slabs of enamel into temporary dental bridges worn by subjects for two weeks. A one-minute-per-day swish of the rinse through the teeth reduced the depth of the buried caries 25 percent more than did saliva exposure alone in similar, artificially developed lesions.

The most widely used of the synthetic-saliva remineralizing solutions was developed about 15 years ago at the University of Rochester by dental pathologist Erling Johansen and chemist Thor O. Olsen. Previously, they had found that certain mineral crystals appeared to survive – even grow – in the acid environment of active caries. Chemical analysis of these crystals showed their fluoride content to be 20- to 30-fold higher than that of normal tooth materials.

"I realized that if I could change the normal crystals to the same chemistry as those observed in the carious lesions, they should have the same cariostatic [properties]," recalls Johansen, now dean of the Tufts School of Dental Medicine in Boston. And the fluoride-and-mouth-rinse treatment that he and colleagues have now used on more than 1,500 persons is designed to do just that.

Twice daily for two weeks, then once daily for another two weeks, patients wear custom fitted "teeth trays" – similar to the tooth protectors worn by athletes – that have been coated with a 2 percent sodium-fluoride-solution gel. (The trays keep the gel close to the tooth surface and keep saliva from washing the gel off the teeth during each five-minute treatment.) To enhance the repair of teeth, several times a day patients swish through their teeth a mouth rinse that is supersaturated with six times the amount of calcium and phosphate present in normal saliva.

Saliva: The first line of defense

"Every time you eat something sweet you produce at least 20 minutes of acid," says Athena Papas, director of the Rubenstein Oral Health Clinic at Tufts University in Boston. Saliva not only washes off the acid but also contributes calcium and phosphate to replace the tooth mineral dissolved by acid attack.

That's why people with impaired salivary glands or reduced saliva flow are particularly susceptible to cavity formation. These individuals, suffering from what is generally termed "dry mouth," aren't able to bathe their teeth in enough of the body's natural remineralizer to offset the demineralization that occurs each time they eat a sweet or drink something acidic, like orange juice.

The severe dry mouth common among patients who have received radiation therapy for head or neck cancer, for example, often leads to such rapid cavity development that individuals can begin losing their teeth to severe decay within a year. For many millions more, dry mouth is a side effect of medication. Boston dentist Michael Stone notes that "in hay fever season we see people get decay who ordinarily would not." The reason? "They're taking antihistamines."

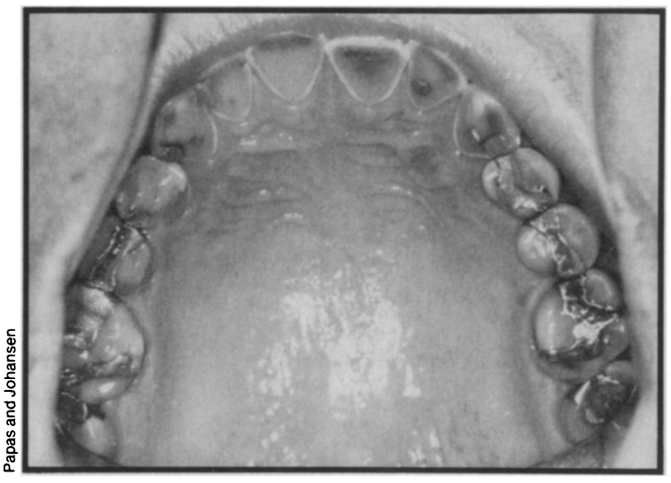
One way to stimulate saliva flow is to chew gum. However, if the salivary gland is impaired or the saliva itself is deficient, gum chewing may not suffice. It was initially to help these people that Erling Johansen and his colleagues at the University of Rochester (N.Y.) developed their fluoride-and-mouth-rinse therapy.

But remineralization is not saliva's only decay-fighting attribute. John Featherstone and his co-workers at the University of Rochester's Eastman Dental Center have found that several classes of organic constituents of saliva – namely phospholipids and phosphoproteins – "adsorb strongly to the crystals of the tooth." Not only are they bactericidal, he says, but they also help neutralize the acidity of the tooth environment. These organic materials may even form a barrier film that partially protects teeth from acid attack, Featherstone says. Similar organic components in cheddar cheese may account for that food's established ability to fight tooth decay, according to a report by the Rochester researchers at the March meeting of the American Association of Dental Research in Washington, D.C.

To date, the month-long and usually one-time therapy has been used to treat people whose decay was unmanageable by their regular dentist – mainly those suffering from "dry mouth" caused by disease, aging, radiation therapy or use of any of some 250 medications, including most antihistamines, antidepressants and heart medicines.

At a scientific meeting last year, Johansen and Athena Papas, director of the Rubenstein Oral Health Center at Tufts, reported on the results of two groups of such patients. One group of 94 treated at Tufts' Rubenstein clinic included patients aged 6 months to 60 years old. Among them, they had 725 carious lesions in tooth roots. After a month's treatment with the intensive fluoride applications, all observable decay had been arrested, the researchers reported. Moreover, the mouth rinses spurred remineralization in an average of 77 percent of the lesions.

The second group involved 34 of the "worst" cases from the private practice of a dentist in Perry, N.Y., a town with unfluoridated water. Prior to treatment, 93 percent had active carious lesions. Not only did treatment arrest their decay, says study director Johansen, but over the remaining four years of the study "no new caries developed."



Papas and Johansen

Bulimia: Stomach acids have entirely eroded the enamel from the backs of upper front teeth in this patient, shown here five years after Tufts fluoride-and-remineralizing program. A single series of the treatments saved the teeth by halting tooth-mineral erosion, rampant decay and painful sensitivity to temperature extremes.

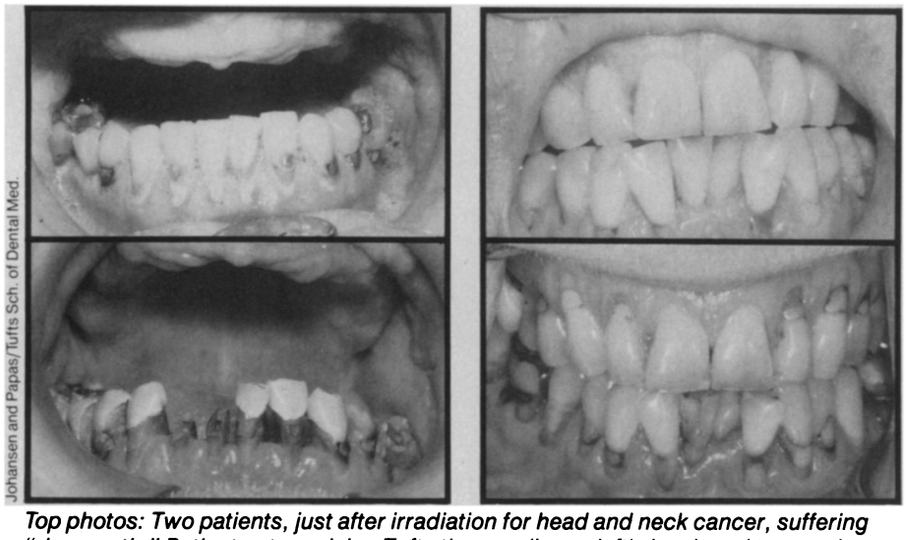
At the March meeting of the American Association of Dental Research in Washington, D.C., Papas and Johansen offered their first report on its use on a small but special class of patients: nine bulimics, individuals who routinely regurgitate food immediately after eating to keep from gaining weight. According to Papas, the Tufts fluoride/remineralizing treatment is the only one so far shown capable of halting a bulimic's tooth destruction.

The hydrochloric acid in vomit can, within a year, completely erode the hard, protective enamel from a bulimic's teeth, leaving them painfully sensitive to extremes in temperature and vulnerable to rampant decay. Ordinarily, if the bulimia isn't halted, stomach acid will eventually erode away tooth material to the point where a full set of crowns will be necessary, Papas says. Such restorative dental work will not necessarily end a bulimic's dental woes, Papas says, because the strong stomach acid that daily washes through the mouth will eventually erode the tooth base onto which any crowns and fillings are anchored.

Before coming for treatment at Tufts, one bulimic patient Papas saw had gone to her dentist weekly to replace fillings that kept falling out. But once treated with the intensive fluoride-and-mouthrinse regimen, Papas says, decay stopped and the porous, carious tissue remineralized. Unfortunately, Papas laments, "although we halted the [acid] erosion, she's still bulimic."

Today this treatment is available only at Tufts or from one of a few Tufts-trained dentists. The real limitation to its wider use, Johansen says, is the availability of the remineralizing chemicals, which are presently being formulated at Tufts. However, Johansen says, negotiations are under way with potential developers to get them onto the commercial market "soon." And once they are available, Johansen says he'll begin classes to train dentists to use the therapy in their own practices.

With advances like these, research is closing in on cavities. Whether marketed as an over-the-counter mouth rinse or a semicustomized prescription treatment, the new remineralizers may someday offer a painless and largely automatic repair of incipient decay. □



Johansen and Papas/Tufts Sch. of Dental Med.

Top photos: Two patients, just after irradiation for head and neck cancer, suffering "dry mouth." Patient not receiving Tufts therapy (lower left) developed tremendous decay and tooth loss in 11 months. Lower right: Ten years after Tufts treatment, this patient's teeth are intact and healthy.