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A B S T R A C T

Athletes who swim intensively, such as those who swim laps more than six hours a week, may develop unusual yellowish brown or dark brown stains on their teeth. The authors hypothesize that long-term contact of the teeth with swimming pool water, as well as the mixture of oral fluids with swimming pool water, leads to the formation of these deposits. The authors report two cases of development of such stains.

INTENSIVE SWIMMING:

CAN IT AFFECT YOUR PATIENTS' SMILES?

KAREN J. ROSE, D.D.S.; CLIFTON M. CAREY, PH.D.

Competitive swimming is a popular sport among young athletes. In 1993, 223,162 swimmers registered with United States Swimming, a national governing body for amateur competitive swimming.¹ The Amateur Athletic Union, another organization in the United States, reported rosters of an additional 7,400 competitive swimmers that year (personal communication, Amateur Athletic Union, 1994). In reality, there are probably more competitive swimmers in this country than those registered with either organization.

To establish a sound swimming technique, young competitive swimmers are encouraged to train rigorously.² Training guides recommend a systematic, structured program to build and maintain the competitive swimmers' best physical condition.^{3,4} These athletes swim thousands of meters and repeat lengthy sets—a set is a series of swimming exercises—with their heads under water. During lap swimming, the teeth are continually exposed to large volumes of swimming pool water⁵ that mixes with fluids in the mouth. Repetitive, long-term exposure of the teeth and oral fluids to chemically treated swimming pool water may cause unusual brown deposits to form on a swimmer's teeth. These deposits have been observed on the teeth of many swimmers who maintain intensive training schedules, even on the teeth of swimmers as young as 5 years (unpublished data, K.J. Rose, 1994).

The deposits are unusual in both their appearance and location. They often are yellow to dark brown and are most noticeable on the facial and lingual surfaces of the anterior teeth. Although they are not usually associated with the advanced signs of gingival inflammation, the stains can be accompanied by gingivitis. The deposits look similar to the yellowish brown extrinsic dental stains reported with the use of chlorhexidine and other cationic surface-active antibacterial mouthwashes. Mandel reported that in studies evaluating these rinses, stains developed within a few days in participants who did not brush their teeth and slightly later and to a lesser extent in participants who did brush.⁶

We first observed these types of stains in a 7-year-old patient who was a competitive swimmer. To identify the cause of these deposits and to provide answers to the parents of other swimmers, we



Figure 1. Case 1. Moderate, gross, supragingival swimmers' calculus that developed on the proximal surfaces of the mandibular incisors in a 9-year-old swimmer. This girl had received dental prophylaxis five months before this photograph was taken. Note the dark brown color of the deposits and the lack of gingivitis, which are typical of swimmers' calculus.



Figure 2. Case 2. Moderate, gross, supragingival swimmers' calculus that developed on the facial surfaces of the mandibular incisors of a 16-year-old swimmer. This girl had received dental prophylaxis four months before this picture was taken. She reported that she brushed her teeth five times a day.

searched the dental literature. We found very little information regarding such deposits. One study conducted in Poland⁷ reported the presence of "unusually brown, hard dental tartar" in 91 of 100 students who trained intensively in swimming. The authors noted that only 27 students in the control group (100 swimmers from "normal" swimming classes) developed the tartar. These authors did not describe the intensity, duration or distance of the swimmers' training; the swim-

ming environment; or the frequency of the participants' dental prophylaxes. Nevertheless, the authors did epidemiologically implicate the swimming environment as the cause for the prevalence of the brown tartar on the teeth of the intensive swimmers.

CASE REPORTS

Parents of children in swim clubs throughout the United States have reported the same type of brown dental deposits developing on their children's teeth to researchers at the American Dental Association Health Founda-

tion. ADAHF researchers have investigated several of the reports and have photographed the teeth of many swimmers who have these stains.

This article describes two typical cases involving patients who swim intensively and accumulated the brown dental deposits.

Case 1. A 9-year-old girl began developing the brown deposits when she was 8 years old, shortly after she began training to become a competitive swimmer (Figure 1). By the

time she was 9, her training schedule included lap swimming for 11 to 15 hours each week. She practiced with her team for about two and a half hours four days during the week and for at least three hours on the weekend.

During this time, she received routine dental prophylaxes every six months, but the deposits were noticeable within three months after a prophylaxis. The stains developed on the facial surfaces of the mandibular anterior teeth and were most pronounced at the proximo-facial line angles. Because the deposits were brown, they were esthetically displeasing. They became more noticeable when the girl trained more intensively.

As is characteristic of this phenomenon, the deposits are not associated with gingival inflammation when the patient is enrolled in a professional dental maintenance program.

Case 2. A 16-year-old competitive swimmer, who began swimming at the age of 7, reported during a dental visit that she had noticed brown deposits on her teeth over the previous year (Figure 2). During this time, she began an intensive training program that included 16 hours of lap swimming each week. She reported swimming five days a week for one and a half hours most mornings and two hours each afternoon. She had received routine dental prophylaxes every six months before the deposits began to form.

The girl's dentist documented that the deposits became noticeable in as little as two months after prophylaxis. The stains, he noted, were generalized on both the facial and lingual surfaces of the patient's teeth, with

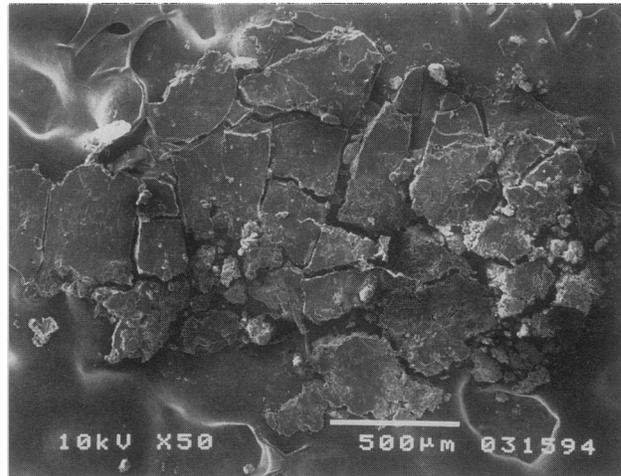


Figure 3. A scanning electron micrograph (X50) of a piece of swimmers' calculus. The sample was dried and gold plated before the SEM analysis according to standard procedures. This low magnification shows that the material is made of flat plates without any gross bacterial adhesion.

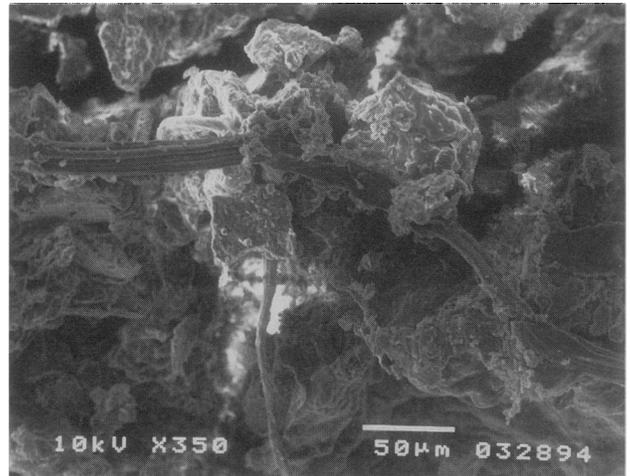


Figure 4. SEM of a second piece of swimmers' calculus at a higher magnification (X350). This micrograph shows significant inclusions within the calculus material. Note the fibers running through the center of this sample.

more extensive buildup on the anterior teeth. The dentist also reported that more effort was necessary to remove these deposits compared to removal of typical dental calculus. Because the patient and her mother both had concerns that swimming had caused the brown dental deposits, the dentist talked with them about the girl's dietary habits, oral hygiene techniques, frequency of toothbrushing and flossing, and medical history, including medication and nutritional supplement use. The dentist identified no other factors that might contribute to the formation of the unusual dental deposits.

The stains continue to form, as noted during follow-up examinations. Because of their dark brown color, the stains are esthetically displeasing and are very noticeable to the girl's friends. She feels that the stains on her teeth are much more pronounced than those that form on her brother's teeth, and she attributes this disparity to the fact that her brother

does not swim as often as she does.

This girl displays signs of mild localized gingival inflammation on the buccal surface of tooth no. 27. Her oral hygiene maintenance program includes an oral prophylaxis every three months. Her oral hygiene at home includes flossing once a day, and she says she brushes up to five times a day on those days when she swims.

DISCUSSION

ADAHF scientists have labeled brown dental deposits that form on the teeth of swimmers as "swimmers' calculus." Researchers from the foundation collected samples of swimmers' calculus from several individuals and used a light microscope and a scanning electron microscope, equipped with electron dispersive X-ray spectroscopy, to examine the samples (Figures 3 and 4). EDS analysis reveals that these samples are made up of two components: a large organic component and a small component of inorganic materi-

al (Figure 5). The organic portion is primarily denatured proteins and some lipids. The denatured proteins are thought to be salivary proteins denatured by the chemical action of the pool water. The inorganic portion is poorly crystallized calcium-phosphate salts.

Dental calculus is made up of organic and inorganic components. The relatively small organic component of calculus (15 to 25 percent) consists of plaque bacteria and bacterial remnants as well as components from saliva and gingival fluid. The larger inorganic component of dental calculus consists of calcium phosphates, magnesium, fluoride and carbonate.^{8,12} Dental calculus rarely forms in children younger than 9 years of age; it usually accumulates in the teen years and becomes more prevalent as a person ages.¹²

By comparison, swimmers' calculus is not rare in children and teen-agers. In fact, in recent surveys of competitive swimmers between the ages of 6

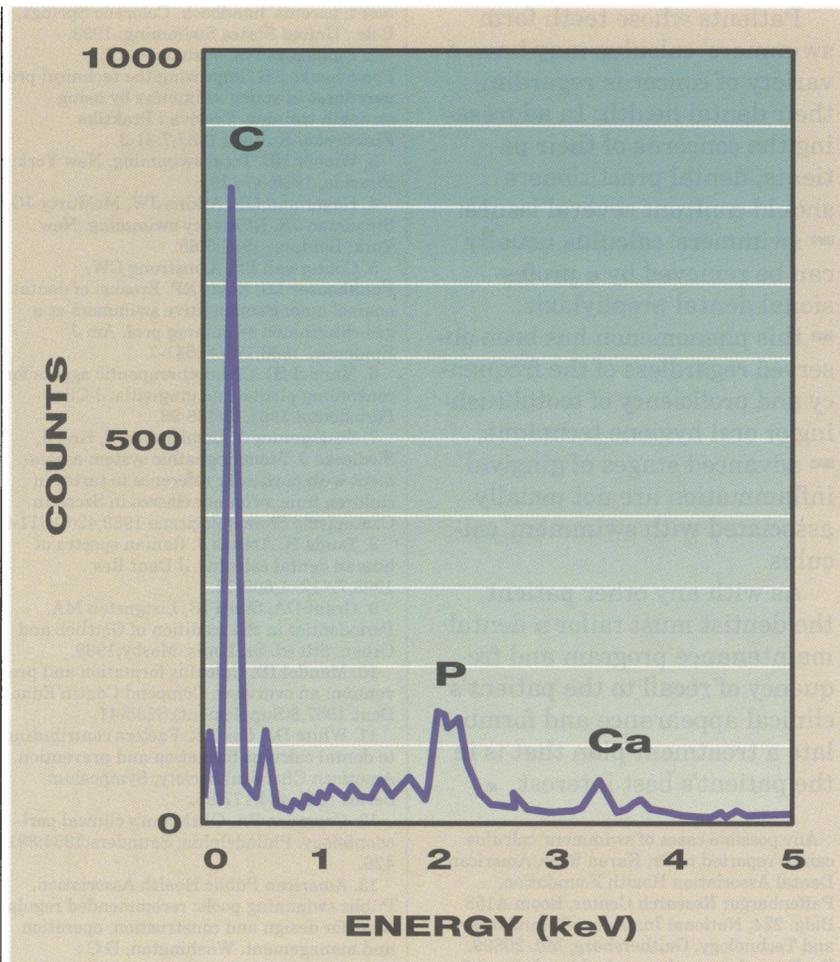


Figure 5. Electron dispersive spectrograph of the swimmers' calculus sample shown in Figure 3. EDS analysis recorded a major peak for carbon, indicating a large organic component, and smaller peaks for calcium and phosphorous are indicative of a minor inorganic component in the sample.

and 18 years, ADAHF researchers found that about 58 percent of those responding have had swimmers' calculus (unpublished data, K.J. Rose, 1994).

The SEM and EDS analysis carried out on these samples indicate that, unlike that of ordinary dental calculus, the organic portion of swimmers' calculus is predominant. We suspect that this portion is made up of denatured proteins derived from the salivary glands and adsorbed to the tooth structure. We also believe that this organic portion is

rapidly denatured by the chemicals in the pool water. EDS analysis also indicates that the small inorganic portion in swimmers' calculus is composed of poorly characterized calcium phosphates that may be adsorbed onto the denatured proteins that coat the teeth.

If salivary proteins are deposited on the teeth of swimmers who train intensively in the same way that they are deposited on the teeth of other individuals—as a pellicle—we propose that the chemicals used to treat pool water cause the proteins to denature more

rapidly and thereby form the organic portion of swimmers' calculus. We base this hypothesis on preliminary data acquired from SEM-EDS microanalysis, polarization microscopy and light microscopy (unpublished data, K.J. Rose, 1994).

The inorganic component also may develop because of the chemicals in swimming pool water. Stringent quality standards make it necessary for swimming pool water to be chemically treated,¹³ which includes the addition of antimicrobials to the water. These chemicals can increase the pH of swimming pool water as compared with that of saliva. The pH of the water at the swimming pools used by the patients mentioned in these case reports averaged 7.6 and 7.4, respectively, which is high compared with human whole saliva's pH of 6.5.¹⁴ The mixture of swimming pool water with oral fluids may lead to the small amount of inorganic material found in swimmers' calculus. Centerwall and colleagues speculated that this mixture results from the breathing technique used by lap swimmers during which the teeth are continually exposed to the pool water.⁵

CONCLUSION

Swimming is an exercise that can be enjoyed throughout one's life, and it is one of the most beneficial forms of exercise for overall fitness. Unfortunately, prolonged exposure to pool water can cause stains to develop on swimmers' teeth.

Swimmers' calculus can be removed routinely by professional dental prophylaxes with the use of an ultrasonic scaler, followed by hand scalers and a

polish with a prophy paste or slurry of pumice. Therefore, it is not recommended that swimmers change their training routine or environment. However, dental practitioners should be aware of the possibility of swimmers' calculus when treating a patient who has a dark brown, hard substance adhering to his or her teeth. When a patient's clinical appearance includes

such dental deposits, we suggest that the dentist ask how often and where the patient swims.



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Patients whose teeth form swimmers' calculus may have a variety of concerns regarding their dental health. In addressing the concerns of their patients, dental practitioners should confront several issues:

- swimmers' calculus usually can be removed by a professional dental prophylaxis;
- this phenomenon has been observed regardless of the frequency and proficiency of toothbrushing or oral hygiene technique;
- advanced stages of gingival inflammation are not usually associated with swimmers' calculus.

As with any other patient, the dentist must tailor a dental maintenance program and frequency of recall to the patient's clinical appearance and formulate a treatment plan that is in the patient's best interest. ■

Any possible cases of swimmers' calculus can be reported to Dr. Karen Rose, American Dental Association Health Foundation, Paffenbarger Research Center, Room A153 Bldg. 224, National Institute of Standards and Technology, Gaithersburg, Md. 20899. Dr. Rose also may be reached by phone at 1-301-975-4282. Dr. Rose may invite such patients to take part in her study or in the foundation's ongoing swimmers' calculus survey.

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