Severe and rapid erosion of dental enamel from swimming: A clinical report

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The diagnosis and treatment of a patient with excessive and rapid erosion of enamel is presented. Although the Center for Disease Control and the dental literature have reported on dental enamel erosion resulting from swimming pool chlorination, the awareness of such etiology among dental professionals may be limited. Common findings in these reports include cold sensitivity, a distinctive appearance resembling laminate veneer preparations of the facial surfaces of anterior teeth, occurrence of diastemas, and at times, a rough or gritty texture of the remaining tooth structure. Clinical presentations of erosive lesions can be diagnosed and the best course of treatment determined. (J Prosthet Dent 2011;106:219-223)

Dental erosion is defined as the pathological loss of dental hard tissues due to the chemical influence of intrinsic or extrinsic acid without bacterial involvement.[1,2] Intrinsic factors include vomiting, regurgitation, and acid reflux. Extrinsic causes include exposure to acidic foods or liquids including soft drinks, sports drinks, fruit juices, carbonated beverages, and sucking on lemons or other citrus fruits.[3-6] Other extrinsic causes of erosion are related to occupational factors[1] as found in those working in wine tasting,[7] in battery manufacturing, electrolytic and galvanizing factories, or fertilizer manufacturers because of their exposure to sulfuric, hydrofluoric, or fluosilicic acids.[1] Additionally, there are reports that poorly chlorinated swimming pools with an acidic pH can cause the erosion of dental enamel.[8-12] The purpose of this clinical report is to describe common causes of dental erosion, with an emphasis on the diagnosis and treatment of a patient with severe and rapid erosion of dental enamel as a result of swimming in an improperly chlorinated pool.

CLINICAL REPORT

A 52-year-old man was referred to New York University College of Dentistry (NYUCD) faculty practice in October 2010 complaining of "extremely sensitive teeth" and with clinical evidence of dark staining and rapid loss of enamel. The patient was accompanied by his spouse, who corroborated this unusual history and presented a dated photograph from 5 months earlier, which revealed an intact dentition. His dental sensitivity to cold and air had developed and progressively worsened over the 5-month period. The patient reported recurrent dental staining despite professional dental prophylaxis. As the condition worsened, he consulted with 2 dentists and 2 physicians before visiting NYUCD. One dentist inquired whether the patient was undergoing treatment for porcelain laminate veneers, because the anterior teeth appeared prepared for such restorations. The dentists found no obvious extrinsic causes, and subsequent referrals to a gastroenterologist and a psychiatrist ruled out intrinsic causes, such as gastroesophageal reflux disease, or eating disorders, such as anorexia or bulimia.[2,6,12-21]

Initial examination revealed a lack of enamel on the facial and occlusal surfaces of the maxillary and mandibular anterior teeth that extended to the second premolars bilaterally. The remaining tooth structure appeared heavily stained, partially porous, and partially glossy, with definitive "finish lines" along the free gingival margins (Figs. 1-3). The apparent loss of enamel structure created diastemas, resulting in poor esthetics.[22-24] There was no evidence of decay, pulpal pathology, changes in the periodontal ligament, or developmental defects. The only other significant dental finding was a retained mandibular right primary molar and a missing right mandibular second premolar. A comprehensive evaluation of his occlusion included: assessment of the relationship of maxillary and mandibular teeth in the physiologic rest position, assessment of occlusal vertical dimension, and vertical dimension of speech. The patient was observed to have maintained adequate posterior occlusal stops on molars during maximum intercuspation (Figs. 2-3)

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1 Frontal view of initial clinical presentation.

2 Preoperative right lateral view depicting loss of tooth structure and maintenance of occlusal vertical dimension on molars.

3 Preoperative left lateral view depicting loss of tooth structure and maintenance of occlusal vertical dimension on molars.

but had an anterior open occlusal relationship. Assessments of horizontal and vertical overlaps revealed a reduction in both. The patient's speech was unaffected and devoid of any hissing or lisping or an acquired "S" sound deficiency.[25] However, upon repeated pronunciation of "S" sounds, while counting from 60 to 70, excessive minimum speech distance in the canine and premolar regions was measured to be 3 to 4 mm. The patient's smile was affected by the deficient length of the remaining tooth structure as well as by the exposed shade of dentin.[22-24] The patient was diagnosed with severe and rapid enamel erosion.

The cause of this rapid erosion was perplexing, and his history warranted further probing. The patient described himself as being an "office type," and so the occupational causes described earlier were ruled out. Gastrointestinal and food disorders were eliminated as causes by physicians and supported by the dental examination, which was contrary to the erosion pattern of intrinsic causes where the lingual surfaces, predominantly of maxillary teeth, are affected.[2,6,12-21] A thorough dietary history ruled out acidic foods or beverages.[2,6,12-21] Coincidentally, 5 months before the examination, the patient had been diagnosed as having multiple hemangiomas of the liver. Although these lesions were of no consequence, his physician had advised him against jogging, fearing spontaneous bleeding. The patient subsequently began an aggressive swimming regimen of 90 minutes of breaststroke daily over the summer months in his home pool. Since improperly chlorinated pool water could be a cause[8-12,26-28] of erosion, the patient was asked about the type of chlorination system and how the pool was maintained. The patient's spouse revealed that a professional pool maintenance service had not been used; rather, the gardener was responsible for maintaining their pool. Subsequently, it was discovered that trichloroisocyanuric acid (trichlor) tablets had been used to chlorinate the 10,000 gallon home pool. Two testing results were examined: the one dated July 2010 showed handwritten results (in quotations) of zero alkalinity, a pH under 7.2, a total chlorine value over 3, a free chlorine of 3.95, and a chlorine stabilizer reading of 35. As a result, the addition of 25 pounds of alkalinity increaser was recommended. The second testing result, from October 2010, showed an improved pH of 7, which led to the addition of 15 pounds of alkalinity increaser. Both readings confirmed pool

acidity. Acidic pool water can also result in burning symptoms in the eyes or skin rashes. The patient admitted to wearing goggles while swimming and revealed that he had been experiencing dermatitis on his right flank. Because of the coincidence in timing of the onset of symptoms and the swimming and by eliminating all other possible causes, the etiology was determined to be improperly chlorinated pool water.

Chlorine is the most commonly used agent to maintain swimming pool pH balance and to inhibit bacterial growth. The pH of a well maintained pool should be between 7.2 and 7.8.[11] There are a number of methods used to chlorinate swimming pools. Gas chlorination is common in large public pools, whereas liquid chlorine (sodium hypochlorite/bleach), granular chlorine (dichloroisocyanuric acid or dichlor), or tablet chlorine (trichloroisocyanuric acid or trichlor) are common in smaller home pools.[26,28] The cyanuric acid stabilizes the chlorine in the presence of sunlight, thus extending its life. If conditions become excessively acidic, a long time spent in the pool, as might happen with young adults and competitive swimmers, can cause irreversible enamel erosion. Reports of pool-associated dental erosion demonstrate that the pH of the water is in the range from 2.7 to 7.[11,26] Although the first reports in the dental literature --involving erosion among competitive swimmers--[12,26] date back to the early 1980s, the awareness of such erosion among dental professionals may be limited. Common findings in these reports include cold sensitivity, distinctive appearance, resembling laminate veneer preparations, of facial of anterior teeth, occurrence of diastemas, and at times, rough or gritty texture of the remaining tooth structure.[8-12,26-28]

The initial treatment phase for the rapid erosion addressed dental sensitivity, extrinsic staining, and prevention of further loss of tooth structure.[5,6] Under local anesthesia, a dental prophylaxis was performed, including a jet of sodium bicarbonate powder (Prophy-Jet; Dentsply Intl, York, Pa) to remove resilient extrinsic staining (Fig. 4). This was done with the patient's informed consent because this procedure mildly abrades the teeth. The patient was prescribed a topical fluoride dentifrice (Previ-Dent 5000 Plus; Colgate Oral Pharmaceuticals, New York, NY) and a paste containing casein phosphopeptide-stabilized amorphous calcium phosphate complexes (CPP-ACP)[29,30] (MI Paste; GC America Inc, Alsip, Ill) for application at home.[5,6,31] The use of other topical desensitizing agents and a dentin bonding agent was considered but not used given their unknown impact on the future bonding of definitive restorations.

4 Frontal view of preoperative clinical presentation after dental prophylaxis cleaning with sodium bicarbonate powder.

Definitive treatment options for excessive enamel erosion include either bonded labial veneers in combination with onlay or complete coverage restoration of the affected teeth.[32] Treatment goals included the elimination of dental sensitivity, replacement of lost tooth structure, correction of teeth proportions and esthetics, and reestablishment of adequate occlusion. Since restoration with laminate veneers constitutes a more conservative approach, veneers were selected as the treatment of choice for the incisors and canines, and adhesively bonded onlays were selected for the premolars. However, a potential concern was that erosion and deficient enamel might affect bonding.

Diagnostic casts and a facebow transfer were made, and the casts were mounted in maximum intercuspation in a semiadjustable articulator (Panadent PSH articulator; Panadent Corp, Colton, Calif). Lateroprotrusive records were used to set the condylar angles.[33] A diagnostic waxing was performed on the casts with a 2 mm horizontal and vertical overlap. Because the interproximal contacts were maintained during erosion, they were used to determine the ideal teeth proportions. The diagnostic casts were duplicated in stone (Microstone; Whip Mix Corp, Louisville, Ky), and subsequently, a 0.5-mm vacuum-formed matrix (Thermo-Forming material; Henry Schein, Melville, NY) was fabricated with these casts. An analysis of the initial diagnostic casts revealed inadequate space for restorative material in the mandibular anterior region, although these teeth showed clear signs of erosion, indicating rapid eruption of the mandibular incisors. Because minimum preparations were planned for the remaining teeth, the vacuum-formed matrix was modified and later used intraorally to serve as an ideal reduction guide for the mandibular anterior region (Fig. 5). The diagnostic waxing was duplicated, a custom incisal guide table was fabricated, and laboratory splinted provisional restorations were

made with a composite resin (Vitalescence; Ultradent Products Inc, South Jordan, Utah).

Since erosion had removed substantial enamel from the facial and occlusal surfaces of the affected teeth, minimal preparations were needed. It was decided to maintain the remaining enamel margins to potentially improve the bonding of restorations. Tooth preparations were limited to the smoothing of sharp edges and the slight opening of interproximal contacts for ease of restorative fabrication in the maxillary incisor and canine regions. The modification of mandibular incisors was done with the reduction guide (Fig. 5), and definitive finish lines were created for onlay preparation on the premolars. In keeping with the treatment goals, the pronunciation of the fricative sounds (F and V) was further evaluated when fabricating the provisional restoration to ascertain whether the proposed maxillary incisal edge met the wet-dry border of the lower lip. Additional evaluation of the patient's speech included the pronunciation of the S-sound, which determined the adequacy of minimum speech distance to be 1 mm. Occlusal assessments ensured that the corrected proportions were adequate in the planned horizontal and vertical planes, thus meeting the patient's esthetic expectations. The diagnostic waxing was, therefore, confirmed as an adequate guide for the dental laboratory technician in the fabrication of the final restorations. Definitive impressions were made with an elastomeric impression material (Medium body Reprosil; Dentsply Intl), and the prefabricated interim composite resin restorations (Vitalescence; Ultradent Products, Inc) were spot etched and bonded (Calibra Esthetic Cement; Dentsply Caulk, Milford, Del) to the prepared teeth (Fig. 6). The impressions were poured in Type IV stone (Fuji Rock EP Die Stone; GC America) and dies were fabricated. The laminate veneer and onlay restorations were waxed to anatomical contour and then cut back approximately 0.6 mm for ceramic application. The wax patterns were sprued and invested, after which the ingots (Ivoclar Vivadent IPS e.max Press LT A3) were pressed following the manufacturer's recommendations. After divestment, the laminates were fitted to the dies and the margins were finished. The restorations were treated with acids (0.6 % hydrofluoric acid and 1.7 % sulfuric acid) for porcelain application (IPS e.max Press Invex Liquid; Ivoclar Vivadent Inc, Amherst, NY), characterized, built up with porcelain, and glazed (Vivadent IPS e.max Ceram; Ivoclar Vivadent

5 Vacuum-formed matrix as preparation reduction guide for mandibular anterior teeth.

6 Buccal view of provisional veneer and onlay restorations.

7 Buccal view of porcelain veneer restorations after cementation.

Inc). The intaglio surfaces of the restorations were treated with hydrofluoric acid (IPS Ceramic Etching Gel; Ivoclar Vivadent Inc) for 20 seconds. Laminate veneers and onlays were evaluated intraorally after a thorough removal of provisional restorations and the polishing of teeth with pumice and water. Definitive restorations were adjusted to a satisfactory fit and occlusion. They were cemented with a composite resin luting agent (Calibra Esthetic Cement; Dentsply Caulk) following the manufacturer's recommendations (Fig. 7). The restoration of occlusion reestablished maximum intercuspation with the restorative replacement of lost tooth structure (with the exception of the retained mandibular right primary molar that was in infraocclusion) and provided the patient with anterior guidance and canine protected occlusion. The patient's pain and sensitivity were eliminated. A combination of laminate veneer therapy and ceramic onlays satisfactorily restored the patient's esthetics, speech, and occlusion. The restorations have been in place for 6 months with no complications.

SUMMARY

The treatment of a patient presenting with rapid erosion of dental enamel caused by poorly maintained pool chlorination is presented. Minimally invasive restorations with laminate veneers and ceramic onlays were selected to address extreme sensitivity and achieve optimal esthetics and function.

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