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ORIGINAL ARTICLE

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Evaluation of prevalence of dental erosion in swimmers in the metropolitan city of India: A cross-sectional study

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Abstract

Introduction: Development and research in medical sciences have increased the life expectancy of the masses resulting in the retention of more teeth in the oral cavity. This leads to the occurrence of various wasting diseases of teeth like attrition, abrasion, and erosion. **Aim and Objectives:** This study evaluates the prevalence of Dental Erosion (DE) and its severity among swimmers of chlorinated pool water in a metropolitan city in India. **Material and Methods:** In this study, 508 young and adult regular swimmers (including competitive swimmers) from various swimming pools were selected and examined clinically for the presence of DE. A structured questionnaire form was formulated to record the history of habitual swimming activity, diet, gastroesophageal reflux disease, history of intake of medications and acidic beverages, etc. for each swimmer. The data obtained were analysed and statistically evaluated. **Result:** Among 508 swimmer participants, 429 were males and 79 were females. Out of these 338 (66.54%), including 293 (57.67%) male and 45 (8.8%) female swimmers showed DE. The mean age of the swimmer was 33.64 years. The majority of swimmers showed Grade I (n=260, 76.92%) type severity followed by Grade II (n=73, 21.59%) and Grade III (n=5, 1.47%). A total of 79 (15.55%) swimmers showed teeth sensitivity. The statistical test showed a positive correlation between the duration of swimming activity and the non-use of dental protective measures with the severity of DE ($P<0.05$). **Conclusion:** Swimmer's erosion is mainly attributed to the acidic pH of pool water associated with chlorine amount and its severity depends upon the duration and period of swimming irrespective of the swimmer's gender.

KEYWORDS

Chlorine; Dental Erosion; Occlusal surface; Swimmer

1 | INTRODUCTION

Development and research in medical sciences have increased the life expectancy of the masses resulting in the retention of more teeth in the oral cavity. This leads to the occurrence of various wasting diseases of teeth like attrition, abrasion, and erosion. In modern society, the prevalence of Dental Erosion (DE) is increasing which may be attributed to changing dietary habits, lifestyles,

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and stress. DE has become a definitive cause for the loss of enamel and dentin due to intrinsic or extrinsic acids. DE may be referred to as, "Progressive irreversible loss of dental hard tissues by a chemical process that does not involve bacterial action".[1] In developing countries like India; the prevalence of DE is increasing drastically due to unhealthy dietary habits like habitual consumption of spicy and acidic food, carbonated beverages, alcohol intake, and on rare occasions as recreational health activities like swimming in chlorinated pool water.[2]

Swimming is considered one of the healthy sports activities but, some health hazards like bodily injury, drowning, respiratory diseases, skin infection, and DE, etc. have been reported with it.[3] DE has remained an undiagnosed or neglected entity by the dentist as well as the swimmer, which affects the swimmer's dentition in many cases. Routinely, disinfection of the swimming pool water is done by the process called "Chlorination"; which turned water pH to acidic and results in the dissolution of enamel and dentin in habitual swimmers.[2] The landmark study was carried out to evaluate the DE in swimmers; where 39% of the regular swimmers showed enamel erosion due to excessive chlorine in the pool water.[2] Very few studies were carried out in the Indian population to evaluate DE in swimmers despite overlooking the fact that over-chlorinated water causes DE. Thus, this study was planned to evaluate the effect of pool water on the swimmer's dentition exhibited as DE.

2 | METHOD

2.1 | Sample size selection:

It was observed that around 100 swimmers visit each week to a swimming pool. For the population size of 700 of seven pools and a confidence level at 99% with margin of error at 3%, a sample size of 508 was established. Accordingly, competitive as well as habitual swimmers were interviewed by the investigator from 7 public swimming pools in, Mumbai and Mumbai sub-urban regions. For the study, the swimmers were selected randomly irrespective of their genders ranging from 14-80 years (mean 33.64 years) and fulfilling the inclusion criteria.

Inclusion criteria:

1. Swimmers aged between 14- 80 years who voluntarily wish to participate in the study.
2. Swimmers who swam for a period of more than 1 year, at least twice weekly and minimum for one hour or more. (For the purpose of the study referred to as 'Regular/ habitual swimmers').
3. Only permanent teeth from the central incisor to the second molars were included for examination and assessment purpose.

Exclusion criteria:

1. Participants who do not wish to participate in the study.
2. Deciduous teeth and third molars.

Among the voluntary participants, 508 regular swimmers were randomly selected and examined by independent clinicians. All prior permissions and ethical approval of the concerned authorities were also acquired for the study. Selected participants were informed about the aim, objectives, and methodology of the study to assure them of their intra-oral examination after obtaining their informed consent.

In a prepared structured questionnaire form a detailed history of swimming activity, diet, medicine intake, etc., was noted. Following the aseptic protocol and using intra-oral mirrors, diagnostic instruments, and using natural as well as artificial white light; all visible surfaces of the teeth were thoroughly examined by the clinician. Clinical examination for the presence, location, and severity of DE was done and intra-oral photographs were taken. Erosive lesions were assessed and their severity was graded according to Lussi's Erosion Index (Table 1).[4] For grading purposes, the higher severity grading was considered for evaluation, in cases where multiple teeth have been involved. Also, to rule out the approximate pH of pool water i.e. acidic, alkaline, or neutral litmus test was used. For this, a drop of pool water sample was placed on a strip of litmus paper, and a change in the color of the paper was noted.

3 | RESULTS

508 regular swimmers were enrolled in the study, including 429 men and 79 women. Out of them, 338 (66.54%) ((293 (57.67%) male and 45 (8.8%) females) have shown DE (Table 2). The age of participants ranged from

14 to 80 years and the mean age of swimmers was 33.64 years (Standard deviation 13.29). In eroded teeth, 84.13% of maxillary central incisors and 32.33% mandibular molar teeth showed higher evidence of tooth erosion (Fig.1 and 2). In swimmers, erosion occurred on both the labial and palatal surfaces of the anterior teeth. A surface-wise distribution revealed that 82.04% of the labial surfaces of maxillary anterior teeth were affected whereas; in 52.99% of mandibular posterior teeth, the occlusal surfaces were affected primarily. The lingual surfaces of the mandibular anterior teeth were the least eroded in only 0.6% of the swimmers (Table 3 and Fig.3). Conclusive results of this study strongly indicate that Grade I (76.92%) DE is the most common in swimmers followed by Grade II (21.59%) and Grade III (1.47%) (Table 4).

Collected data were analyzed using the Statistical Package for Social Sciences (SPSS v 21.0, IBM). Descriptive statistics like mean age and gender-wise distribution have been depicted. Comparison of frequencies of subjects with erosion, teeth sensitivity, the severity of dental erosion, and affecting tooth tissue with groups was done using the Chi-square test. For all the statistical evaluation tests, $p<0.05$ was considered to be statistically significant.

4 | DISCUSSION

The current advances in medical science and technology have extended the lifespan of people leading to the retention of their natural teeth in the oral cavity for more years. As a result, natural teeth are subjected to greater wear and tear in the form of wasting diseases of teeth like attrition, abrasion, and erosion. Imfeld et al. referred to Dental Erosion (DE) as, "The pathologic loss of dental hard tissues due to the chemical influence of extrinsic and intrinsic acids without bacterial involvement."[5]

DE is usually caused by intrinsic or extrinsic acids and it has often been overlooked in routine dental practice due to a lack of awareness among dental professionals as well as by the common masses due to its low incidence, multi-factorial etiology, and similar clinical characteristics with other tooth wearing defects.

Unlike caries, DE is usually diagnosed clinically by its appearance rather than catching the tooth defect.[6-9] It is also diagnosed primarily by obtaining the patient's dietary, medical, behavioural, and occupational history.[10] Diagnostic casts of the occlusal table are often advised for the detection of the progress of DE over a period of time. Newer laboratory methods such as Surface Profilometry, Scanning Electron Microscopy (SEM), Confocal Laser Microscope (CLM), etc. showed promising results in the analysis of DE in in-vitro studies.[11-13]

Clinically, erosion has smooth or eroded concavities within the surface enamel, cupping of occlusal surfaces (or incisal grooving), and may show exposed dentin. Incisal edges of anterior teeth become translucent due to the dissolution of palatal enamel. Protrusion of restorations is exhibited above the cavosurface margin and referred to as raised or proud restoration due to the dissolution of enamel and dentin at the margins of the restoration.[14,15]

Among various intrinsic and extrinsic factors responsible for DE, swimming is considered as one of the potential extrinsic factors in the present health-aware people. Globally, swimming is one of the enjoyable physical activities and a recognized sport that may be associated with physical strain, fitness as well as erosion of the enamel.[16-18]

The maintenance and pH of swimming pool water play a vital role in the introduction of DE. Generally, disinfection of the swimming pool water has been done using various methods like chlorine gas, chlorine compounds, ultraviolet (UV) lights, or ozone gas.[19] In the routine course, for disinfection purposes of swimming pools; chlorine levels should be maintained between 1.0 to 3.0 ppm (Centre for Disease Control and Prevention, 2010). Unfortunately, the chlorine products used for disinfection also reduce the pH of the water and make it acidic.[20] World Health Organization (WHO) has recommended that the levels of free chlorine in public pools must be less than 3 mg/L or 3 ppm.[21] The recommended pH of pool water should be between 7.2-8.0; whereas in the over-chlorinated pool water, it is below the critical pH i.e. below 5.5. This acidic water causes the dissolution of surface enamel and dentin by the process called DE of the swimmer's dentition. In India, these International standards laid down by WHO and CDC are usually followed as guidelines for pool water maintenance with

few modifications as per the pool size which may be decided by local authorities.

The first evidence of DE was reported by Savad in 1982, where some swimmers had erosion of enamel due to excessive chlorine in the pool water.[22] A pioneer study carried out in September 1982 by Centerwall, B.S. Armstrong, Charlottesville, Virginia, found enamel erosion in 39% regular swimmers which was observed to be associated with the low pH (2.7) of the water. They coined the term, "Swimmer's erosion" and described it as, "A painful and irreversible condition caused by improperly maintained chlorinated water."[2]

In another study, 100 young (75 males and 25 female) competitive swimmers were examined for DE; and observed that 90% showed DE which was directly proportional to the duration of swimming. In this population, 94% exhibited rough surfaces whereas; 88% have a varying degree of pain in the teeth.[23]

Geurtsen reported a case where a competitive swimmer had severe erosion of the enamel of maxillary incisors and other teeth within 27 days of swimming; which was related to intensive swimming in the over-chlorinated pool water. The author also noted that the teeth do not show any signs of DE in the pH-adjusted or non-acidic pool water i.e. pH 7.2 and 8.0.[24,25]

A case of rapid and severe dental erosion in a male swimmer was reported by Jahangiri L. et al. without any contributory history of any intrinsic or extrinsic causes except swimming in a overchlotinated pool water.[26] Dawes and Boroditsky have described a rare case of a woman swimmer; who swam for 2 weeks for more than 2 hours daily in an improperly maintained swimming pool in Cuba and showed generalized wearing of enamel by erosion.[27] Controversial results were observed where only 0.14% of swimmers of Dutch swimming pools with pH below 5.5 showed DE.[20] Controversial results were observed where only 0.14% of swimmers of Dutch swimming pools with pH below 5.5 showed DE.[20]

In this study, the pH of all pool water was measured using a litmus test and found to be below recommended pH i.e. acidic. The blue litmus paper turns red with the addition of sample water on it, indicating a pH range between 4.5 to 8.3. When this paper turns purple, it indicates the neutral pH of pool water. Though, it is a quick and simple method; it is not an accurate indicator of pH. Also, due to the bleaching action of chlorine, few samples turned white resulting in false negative results. Although, all pool authorities agreed about maintaining the pool water for public use following local guidelines by periodic quality check of pool water twice daily; the observations made were not in their assertion. The tooth erosion was reported to be as Grade I in 260 (76.92%), Grade II in 73 (21.59%), and Grade III in 5 (1.47%) swimmers (Table 4) in this study.

During the examination, the time lapse between tooth brushing and swimming was asked to the participating swimmers. It was observed that 124 (24.80%) swimmers brushed their teeth before the swimming, 130 (26%) brushed immediately after, and 246 (49.20%) brushed after a few minutes to an hour of swimming. A strange finding was evident that the swimmers who brush immediately after coming out of the swimming pool showed higher grades of (Grade II) DE than those who brushed before swimming or swam after some time (No or Grade I Erosion). From these observations, it can be contemplated that the chlorinated water entering the oral cavity may have dissolved the inorganic tooth structure with loss of enamel and dentin by means of erosion. Brushing the teeth immediately accelerates the tooth surface loss by the mechanical or abrasive action of the brush. Again, when this abraded surface is re-exposed to acidic water, it becomes more vulnerable to high-grade erosion than the previous exposure.

Only 24 swimmers (4.72%) used mouth guards while swimming, and none of them displayed any signs of DE. Whereas, the remaining 484 (95.27%) swimmers (without mouth-guards) showed a higher degree of tooth erosion. It might be concluded that the mouth-guard is a definite protective barrier against DE and it is advisable to be used every time while swimming. The majority of the swimmers have shown DE in one or more teeth, but they were not aware of this condition. In our study, only 79 (15.55%) swimmers have complained of yellowish or brownish discoloration of their teeth with sensitivity (Table 5). Thus, factors responsible for DE should be diagnosed early and treated promptly to prevent permanent

damage to the tooth structure. The use of fluoride varnishes and desensitizing agents may prevent the erosive loss of swimmer'dentition.

The reason for conducting this study is to rule out the prevalence of DE and to create awareness among the swimmers regarding the erosive tooth loss of their dentition. Also, DE can be considered admissible evidence for a person having some specific dietary or recreational history. This study highlights need of the use protective measures to prevent erosion among swimmers at early stages. further, this will improve the dental health status of the swimmers and enable them to have a healthy dentition and life.

5 | LIMITATION

Dental Erosion is a multifactorial clinical entity where dietary factors play a vital role in its diagnosis and occurrence. Similarly, other contributing factors also have their role concurrently; thus, the exclusive role of each contributory factor would be difficult to rule out in erosion in likewise studies. Advanced methods to check the exact pH of pool water should be employed after seeking permission from the respective authority.

6 | RECOMMENDATIONS

1. It is recommended to create awareness among the swimmers regarding dental erosion due to high chlorine content in the pool water and advised them of proper protective measures before their registration for swimming to safeguard the interest of swimmer's health.
2. It is advisable to have regular, periodic monitoring of the pH level of the pool water to be maintained at recommended levels.
3. Mouth-guards are recommended to avoid dental erosion for regular swimmers and need to be periodically checked for their proper fit and usage.

7 | CONCLUSION

Dental erosion is usually associated with intrinsic acid exposure to the teeth. Swimming in over-chlorinated pool water being an extrinsic cause induces DE of varying degrees depending upon the duration of intense swimming, the pH of the water, and the use of protective measures. The occurrence of dental erosion in regular swimmers could be considered a definitive marker for the presence of excessive chlorine with acidic pH of the pool water and vice versa.

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Conflict of interest

The authors have no conflicts of interest to declare.

Supporting Information

Additional supporting information may be found at the journal's website.

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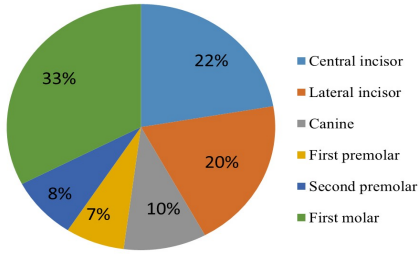

FIGURE 1 Dental erosion in maxillary teeth

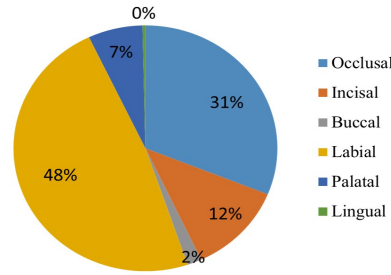

FIGURE 3 Surface-wise distribution of DE in all teeth

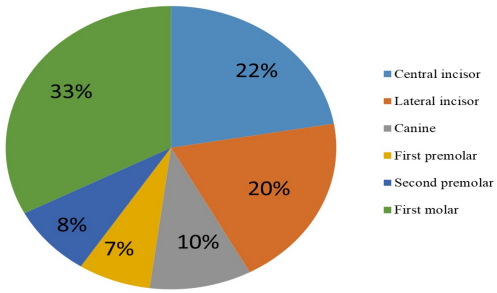

FIGURE 2 Dental erosion in mandibular teeth