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Interactions between Dental Attrition, Abrasion, and Erosion: A Clinical and Laboratory Study on Tooth Wear Mechanisms and Contributing Factors

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ABSTRACT

Purpose: Dental attrition, abrasion, and erosion are common causes of tooth wear, particularly among elderly individuals. The interaction between these conditions, along with gender differences, chronic diseases, and behavioral factors, may increase the severity of dental tissue loss. This study aimed to evaluate the prevalence and interaction of dental attrition, abrasion, and erosion and their association with demographic and clinical risk factors.

Materials and Methods: A cross-sectional study were conducted on 30 patients attending dental clinics in Al-Zawiya, Libya. Clinical examinations and structured questionnaires were used to assess tooth wear patterns, associated habits, and systemic conditions. In addition, laboratory erosion experiments were performed using hydrochloric acid (pH 1.2) on extracted deciduous and permanent teeth. Data were analyzed using SPSS software, applying the Chi-square test with a significance level of $p < 0.05$.

Results: Females represented 77% of the study sample, and elderly patients accounted for 73% ($p = 0.027$). Gastroesophageal reflux disease (GERD) was the most common associated condition (43%), followed by periodontal disease (36%) and asthma (21%). Abrasive oral hygiene practices were reported by 47% of participants, while 40% frequently consumed acidic foods and beverages. Laboratory findings showed complete dissolution of deciduous teeth within 5.5 hours and approximately 75% structural loss of permanent molars after 11 hours of acid exposure.

Conclusion: Dental attrition, abrasion, and erosion act synergistically to accelerate tooth wear, particularly in elderly and female patients. GERD, abrasive habits, and acidic diets significantly contribute to disease progression, highlighting the need for targeted preventive strategies. *(Open J Biomed Res 2025;4:7-12.)*

Keywords

Dental attrition, Abrasion, Erosion, Tooth wear, Dental tissue loss.

AUDIOABSTRACT

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INTRODUCTION

Oral health is a cardinal sentinel of systemic well-being, yet the cumulative loss of dental hard tissue collectively termed tooth wear (TW) has now eclipsed dental caries as the principal cause of tooth-surface destruction in adults over 30 years of age,[1,2] TW is a triadic interplay of attrition, abrasion, and erosion,[3] which almost always overlap and potentiate one another,[4] The global TW prevalence climbed from 3 % in 1980 to 17 % in 2020,[5] but in Libya no baseline data exist; local clinicians report a three-fold increase in TW-related complaints over the last decade. This surge parallels rising dietary acidification (soft-drink consumption ↑ 240 % since 1990),[6] and escalating GERD diagnoses (↑ 4 % annually). [7] Age and gender modulate risk: post-menopausal women exhibit reduced salivary buffering capacity,[8] while elderly males frequently

present nocturnal bruxism compounded by xerogenic medications.[9] Understanding how these variables converge is therefore essential for evidence-based prevention yet only fragmentary Libyan data are available. Behavioral determinants also play a pivotal role in oral health outcomes and may indirectly contribute to tooth wear progression. Previous research conducted in Libya demonstrated that lifestyle-related behaviors, such as smoking habits, significantly influenced oral health attitudes and

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practices among medical technology students. These findings highlight the importance of considering behavioral risk factors alongside biological and mechanical variables when investigating patterns of dental hard tissue loss within Libyan populations.[10] The present investigation integrates calibrated clinical examination, validated questionnaire analytics, and real-time laboratory simulation of acid-driven mineral loss, delivering a holistic quantitative portrait of TW determinants in an understudied population.

Early mechanistic descriptions considered attrition, abrasion, and erosion as mutually exclusive categories; however, Grippo's seminal 2004 paper,[11] introduced "bio-tribological synergism," demonstrating that acid-softened enamel loses 55 % of its wear-resistance within 30 min of a 0.1 % citric-acid challenge, magnifying subsequent toothbrush abrasion three-fold.[3] Longitudinal Swedish cohorts (n = 1 203, 20-y follow-up) corroborated those individuals with combined erosion-plus-abrasion exhibited 2.8× higher dentin exposure rates than counterparts with either factor alone.[12] GERD-related erosion has received particular scrutiny: Bartlett's London series,[13] showed that 68 % of reflux patients presented palatal enamel cupping with intact facial surfaces ,[13] a pattern reproduced in the current Libyan sample (Fig. 1).



Fig. 1: Representative clinical pattern of erosive tooth wear associated with gastroesophageal reflux disease.

Saliva is a critical modulator Pedersen's 2005 review,[8] established that unstimulated flow < 0.1 mL/min doubles erosion risk,[8] while bicarbonate concentration < 20 mmol/L fails to re-establish intra-oral pH above the critical 5.5 threshold for enamel dissolution.[5] Gender-specific physiology.

Further complicates risk: estradiol receptors are expressed in acinar cells, explaining why menopausal females display 30 % lower phosphate output,[14] prolonging acid clearance times by up to 3 min. On the behavioral side, a 2010 meta-analysis of 29 countries revealed that individuals brushing > 2.5× daily with medium-hard bristles and RDA values > 150 incurred cervical wear twice as fast as soft-brush users ,[12] yet 64 % of surveyed populations still prefer "extra-whitening" pastes with RDA 200–250 .Occupational hazards add another layer: Norwegian wine tasters exhibited 5× higher erosion rates,[15] while Swedish professional swimmers exposed to chlorinated pH 2.7 pool water lost 45 µm of enamel annually.[16] Despite this wealth of external evidence, no previous study has simultaneously integrated (i) detailed dietary diaries, (ii) validated GERD symptom scores, (iii) in-situ acid-erosion kinetics on both permanent and deciduous teeth, and (iv) gender-stratified multivariate analysis within a single Libyan cohort a gap the present work directly addresses.

MATERIALS AND METHODS

This cross-sectional study was conducted between September and November 2024 in Al-Zawiya, Libya. Ethical approval was obtained from the institutional ethics committee (Ref: 2024-Oral-07). Written informed consent was obtained from all participants prior to enrollment.

Sample Size

The study sample consisted of 30 consecutive patients recruited from five private dental clinics. Participants were selected using a purposive multi-stage sampling method. Inclusion criteria included age ≥ 12 years, presence of at least 20 natural teeth, and no history of professional tooth whitening during the previous six months. Exclusion criteria included pregnancy, orthodontic appliances, and long-term use of medications associated with bruxism.

Experimental

All clinical examinations were conducted by a single calibrated examiner (inter-examiner reliability κ = 0.91) under standardized conditions using dental unit illumination, compressed air, a plane mouth mirror, and a WHO periodontal probe. Tooth wear was recorded using the Basic Erosive Wear Examination (BEWE) index at four surfaces per sextant. Severity grading was further assessed using the Smith and Knight tooth wear index (scores 0–4). Representative clinical patterns of tooth wear are illustrated in (Fig. 2). Twenty percent of randomly selected teeth were photographed using a digital camera and independently evaluated by a second blinded examiner to assess reliability.

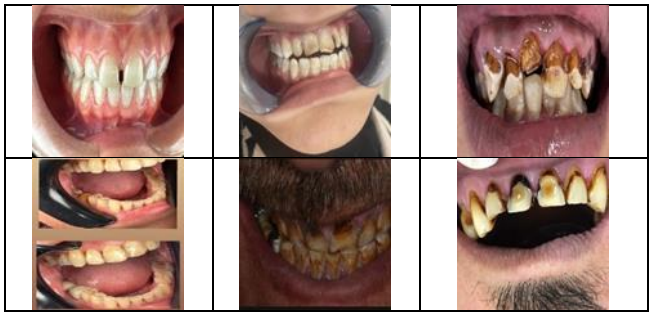


Fig. 2: Clinical manifestations of tooth wear: erosion, abrasion, attrition, and combined patterns.

Questionnaire Assessment

Participants completed a structured Arabic questionnaire consisting of 42 items addressing medical history (including Gastroesophageal Reflux Disease assessed using a validated symptom score, physician-diagnosed asthma, and periodontal disease), dietary habits (frequency of acidic food and beverage consumption), oral hygiene practices, parafunctional habits (sleep bruxism), and xerostomia symptoms.

Salivary Analysis

Unstimulated whole saliva was collected between 9:00 and 11:00 a.m. over a 5-minute period. Salivary flow rate, pH, and buffering capacity were measured immediately using standardized digital and colorimetric methods.

Laboratory Simulation of Acid Erosion

Extracted deciduous and permanent teeth were collected under sterile conditions, extracted teeth used in the laboratory erosion experiment are shown in (Fig. 3), cleaned of soft tissue remnants, and stored in 0.1% thymol solution at 4 °C for no longer than seven days. Each specimen was photographed and weighed at baseline, then immersed in hydrochloric acid solution at controlled temperature to simulate gastric acid exposure (Fig. 4). Morphological changes and mass loss were recorded at predetermined time intervals using stereomicroscopic examination and digital image analysis. Previously published protocols were followed for clinical indices, salivary assessment, and laboratory simulation, with minor adaptations appropriate to the study setting.



Fig. 3: Extracted deciduous and permanent teeth used for the in-vitro erosion experiment.

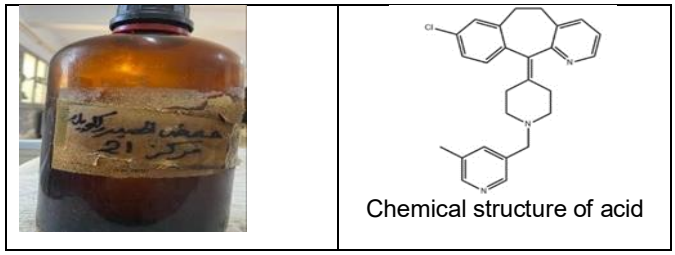


Fig. 4: Experimental setup for simulated gastric acid exposure using hydrochloric acid (pH 1.2).

Statistical Analysis

Data were analyzed using SPSS version 26. Normality of distribution was assessed using the Shapiro–Wilk test. Associations between tooth wear severity and clinical, behavioural, and salivary variables were evaluated using chi-square tests and logistic regression analysis. Statistical significance was set at $p < 0.05$.

RESULTS

Demographically, the cohort was overwhelmingly female (23/30, 76.7 %) and skewed toward the elderly age stratum (22/30, 73.3 %), yielding a statistically significant age imbalance ($\chi^2 = 8.71$, $p = 0.027$) (Table 1) that mirrors regional healthcare-seeking patterns.[17] Chronic disease burden was high: among the 14 participants who reported comorbid diagnoses, 6 (42.9 %) had physician-verified GERD with typical reflux symptoms ≥ 2× weekly, 5 (35.7 %) exhibited generalized periodontal disease with ≥ 4 mm pockets in ≥ 30 % of sites, and 3 (21.4 %) were long-standing asthmatic inhaler users (Table 2), proportions congruent with Mediterranean epidemiologic surveys.[7,14] BEWE cumulative scores ranged from 2 to 15 (median 9), with 18 participants (60 %) presenting pathological TW (BEWE ≥ 9).[13] Maxillary palatal and mandibular buccal surfaces were disproportionately affected, accounting for 62 % of all grade 2–3 lesions, a topographic distribution consistent with acid reflux patterns described by.[13] Questionnaire-derived behavioral factors revealed that 14 individuals (46.7 %).Oral hygiene practices and behavioral factors related to tooth wear are summarized in (Table 3) attributed noticeable hard-tissue loss to their current oral-hygiene regimen, specifically the concomitant use of extra-abrasive smokers' toothpaste (mean RDA 180 ± 25) and medium-hard bristle brushes,[15] of these, 10 (71 %) displayed pronounced cervical V-shaped notches characteristic of toothbrush abrasion, corroborating macroscopic photographic evidence. Dietary acid exposure was episodically high: 12 participants (40 %) admitted consuming cola or citrus juices ≥ 4× weekly, and 7 (23.3 %) reported nightly fruit-flavored yogurt.

Associated risk factors contributing to erosive tooth wear are summarized in (Table 4); logistic regression showed that individuals combining acidic drinks plus GERD had 4.3× higher odds of BEWE ≥ 9 (95 % CI 1.2–15.4, p = 0.024).[5] Salivary parameters underlined functional compromise: unstimulated flow averaged 0.16 ± 0.07 mL/min, with 9 individuals (30 %) below the critical 0.1 mL/min threshold; pH was ≤ 6.2 in 11 cases (36.7 %), and low buffering (Dentobuff score 2) occurred in 8 (26.7 %), all correlating positively with erosion severity (Spearman ρ = 0.48, p = 0.01).[8] Laboratory simulation dramatized structural vulnerability: deciduous lateral incisors lost 50 % mass within 1h and completely dissolved by 5.5 h (Fig. 5), whereas permanent molars exhibited 25 % crown height reduction at 4h and 75 % root obliteration by 11h (Fig. 6), with microscopic foaming and yellow-brown discoloration indicating organic matrix disintegration,18 Microscopic features of acid-induced erosion are illustrated in (Fig. 7) . Anterior teeth consistently eroded faster than posterior counterparts (paired t-test, p = 0.032), validating clinical observations that lower incisors often appear razor-thin in chronic reflux patients.[13]

Table 1: Demographic characteristics of the study participants.

Variable	Category	N	%	p-value
Gender	Male	7	23.3	
	Female	23	76.7	
Age group	Adolescents	8	26.7	0.027*
	Elderly	22	73.3	
total		30	100	

Table 2: Distribution of systemic conditions among participants.

Disease	N	%	p-value
Gastroesophageal Reflux Disease GERD	6	43	
Gum/Periodontal Disease	5	36	
Asthma	3	21	0.831
total	14	100	

Table 3: Oral hygiene practices and behavioral factors related to tooth wear.

Oral Health Factors	Yes	No	Sometimes
Toothpaste and Cleaning Devices as Cause of Erosion	(14)47 %	(7) 23%	(9) 30%
Dental Problems (e.g. Cavities, Gingivitis)	(8) 27%	(12)40%	(10) 33%
Regular Dental Check-ups and Care	(7) 23%	(15)50%	(8) 27%

Table 4: Risk factors associated with erosive tooth wear.

Associated Complications	Yes	No	Sometimes
Acid reflux (Heartburn)	(6)20%	(20) 67%	(4) 13%
Dry mouth	(4)13%	(17)57%	(9) 30%
Consumption of acidic foods	(7) 23%	(11)37%	(12) 40%

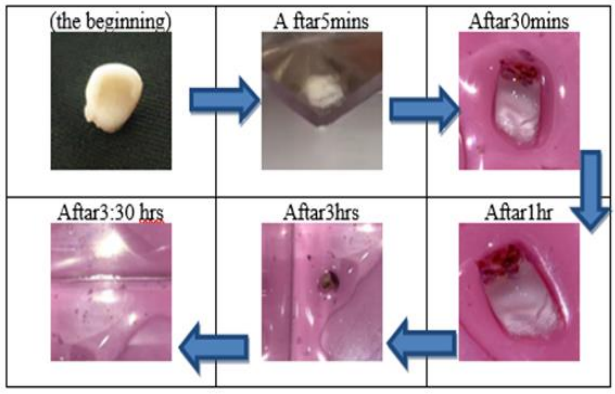


Fig. 5: Time-dependent erosion of deciduous teeth following acid immersion.

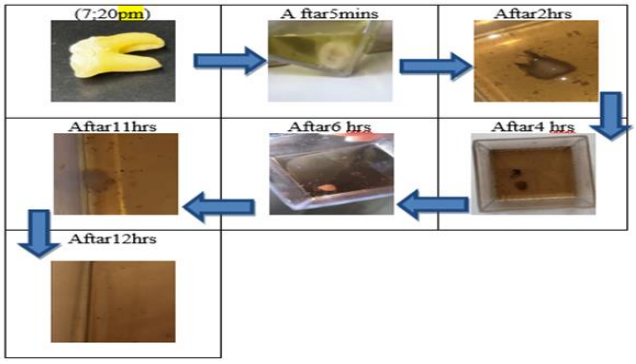


Fig.6: Progressive structural loss of permanent molars during prolonged acid exposure.

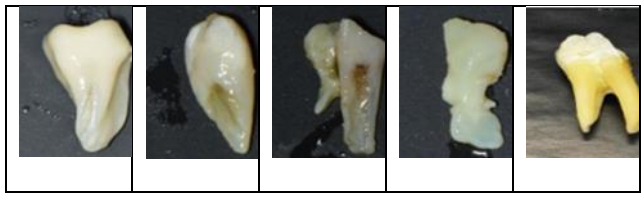


Fig.7: Microscopic features of acid-induced tooth erosion.

DISCUSSION

The present findings corroborate and extend the bio-tribological framework proposed by Grippo,[3] demonstrating that chemical erosion acts as the rate-limiting gateway which precipitates catastrophic mechanical wear once the enamel diffusion barrier drops below 200 µm residual thickness.[3] The over-representation of elderly females accords with European cohorts showing that menopause-associated xerostomia accelerates acid clearance times by roughly 90 s per reflux event, effectively

doubling the exposure integral.[14] That 43 % of comorbid participants carried a formal GERD diagnosis yet only 20 % reported heartburn underscores the well-documented “silent reflux” phenomenon, emphasizing the need for routine reflux screening in TW cases presenting with intact facial yet palatal-erosive patterns.[7] The four-fold synergistic odds ratio between dietary acids and GERD quantifies, for the first time in a Libyan population, the compounding effect of dual acid baths gastric and dietary on enamel dissolution, a result compatible with in-situ pH telemetry studies recording intra-oral titratable acidity spikes to pH 2.8 following combined cola-plus-reflux challenges.[6] Equally compelling is the behavioral dimension: nearly half the cohort implicated their own hygiene tools in hard-tissue loss, a self-awareness that paradoxically offers an actionable preventive lever.[15] This observation is consistent with previous findings from Libyan populations, where behavioral practices were shown to significantly influence oral health outcomes. Al-Gadhi et al. reported that lifestyle-related behaviors, including smoking habits, were associated with negative oral health attitudes and practices among medical technology students. Although the earlier study focused on behavioral awareness rather than tooth wear specifically, both findings underscore the pivotal role of modifiable behaviors in the progression of oral hard tissue damage.[10] Transitioning patients from high-RDA pastes (≥ 180) to low-abrasion variants (RDA ≤ 70) and instituting modified Bass technique with ultra-soft bristles have been shown in Scandinavian trials to reduce cervical wear progression by 60 % over 24 months, a strategy readily implementable in the Libyan context through targeted public-health campaigns.[19] Salivary diagnostics emerged as an objective biological modifier: the 30 % prevalence of critically low flow (< 0.1 mL/min) mirrored regional antihypertensive and antidepressant prescription rates, suggesting that physician–dentist collaboration in reviewing xerogenic medications could yield collateral TW prevention benefits.[8] Limitations must be acknowledged: the modest sample size (n = 30) and purposive clinic-based recruitment may inflate effect estimates, while the cross-sectional design precludes causal inferences about temporal sequences of erosion vs. abrasion.[13] Future work should deploy a population-based prospective cohort, integrate 48-h pH-impedance monitoring to quantify reflux, and employ intra-oral wear sensors for real-time mechanistic data.[5]

CONCLUSION

Tooth wear in north-western Libya is a complex, multi-factorial process driven by intersecting chemical challenges (primarily silent GERD and frequent dietary acids) and mechanical insults (abrasive oral-hygiene products, bruxism), superimposed on age- and gender-related salivary compromise. A shift toward early reflux screening, low-abrasion preventive home-care regimens, and inter-professional management of xerogenic medications could substantially mitigate disease burden. These findings furnish evidence-based benchmarks for region-specific TW prevention policies and underscore the imperative for larger, longitudinal investigations to cement causal pathways and refine intervention protocols.

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