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Dental erosion, soft-drink intake, and oral health in young Saudi men, and the development of a system for assessing erosive anterior tooth wear

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Dental erosion, soft-drink intake, and oral health in young Saudi men, and the development of a system for assessing erosive anterior tooth wear

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The aim of the study was to investigate some aspects of the oral health of male Saudi military inductees with special reference to soft-drink consumption, dental erosion, caries and fluorosis prevalences; a second aim of the study was to develop a system for assessing dental erosion. The material comprised a random selection of 95 individuals with a mean age of 20.9 years (range, 19–25 years). A questionnaire survey was made of each individual's dietary and oral hygiene habits and general and oral health, in addition to clinical, study cast, radiographic, and photographic examinations. The results showed that soft-drink consumption in the sample ($\bar{x}$ = 247 l/year) far exceeded that found in Western populations and that professional and self-administered dental care were generally scant. Twenty-eight per cent of the maxillary anterior teeth showed pronounced dental erosion. Fluorosis was a common finding, and the number of untreated carious cavities was high. DMFT ($\bar{x}$ = 10.0; DT = 7.7; MT = 0.5; FT = 1.8) and DMFS ($\bar{x}$ =18.3; DS = 12.6; MS = 2.5; FS = 3.2) were higher than those of comparable Western populations and showed an approximately threefold increase over a period of about 18 years as compared with that previously reported in a similar Saudi sample. In view of the high frequencies of dental erosion, untreated carious cavities, and fluorosis reported here and the strong indication of an increasing caries prevalence, the need for serious recognition of the implications in the planning of future dental health care programs is stressed. ☐ *Dental caries; diet; fluorosis; oral hygiene; tooth erosion*

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The Kingdom of Saudi Arabia is the largest of several countries located on the Arabian peninsula, occupying approximately 80% of its total land mass. From a mainly nomadic existence, the population has, over the past 2 to 3 decades, experienced unparalleled development. The size of the population has increased about fourfold since the beginning of the 1960s, and, with this, there has been a large relocation from rural to urban areas and a concomitant shift towards urban lifestyles (1).

The present generation of young Saudis have spent most of their lives in the oil boom period, which started in the late 1960s. In such rapidly changing social and economic environments, dietary alterations are inevitable, and regular promotional drives and incessant advertising carried out by the media, frequently targeting the young, have undoubtedly played a significant role in modifying dietary habits. The deleterious effects of, for example, increased consumption of refined carbohydrates, as in sweets and soft drinks, on oral health have previously been reported (2, 3).

Of special concern in the Arabian peninsula is the climate, which most likely affects the diet. The terrain is largely desert with extremely hot climatic conditions for most of the year. Fluid intake and, in particular, consumption of beverages are high. Among the soft drinks, cola-type drinks are the most frequently consumed. The mechanisms by which such beverages, and their frequently present caffeine content, affect oral health (2–10) and also general health (11, 12) have gained considerable interest in the literature.

Fluorosis is a common finding in several areas of Saudi Arabia (13, 14) and can partly be ascribed to the use of uncontrolled wells as a source of drinking water by local communities. In addition, high ambient temperature and altitude are factors that are known to increase the degree of fluorosis (15), factors clearly present in the Saudi environment. Apart from esthetic implications, fluorosis has been extensively investigated in relation to caries prevalence and is also possibly associated with the development of tooth wear (16). All of these problems, in addition to a high prevalence of untreated caries, are commonly observed in the Saudi population (13).

Tooth wear in young adult Saudis has been the subject of several investigations. It has been shown that the severity of tooth wear in Saudis significantly exceeds that found in similarly aged Western populations (17). Tooth wear has a multifactorial etiology and is also frequently the result of more than a single wear-producing mechanism (17, 18). In the cited Saudi

studies, however, no distinction was made among erosive, attritional, and abrasive influences (17). Clinical detection of early signs of erosive wear is difficult, because of the likely concurrent processes of abrasion, erosion, and attrition, which are, or may have been, responsible for the observed condition (19–21). Nevertheless, severe dental erosive wear has frequently been observed by us in the Saudi population, although its prevalence and severity remain unreported.

Given the observations of high prevalences of caries, fluorosis, tooth wear and dental erosion in particular, it is evident that the Saudi community presents a special pattern of oral problems. It is the purpose of this study, therefore, to investigate and report on the oral health of young Saudi inductees by means of a questionnaire and clinical examination. Further statistical analyses of dental erosion and its etiologic associations, in addition to the results of some other correlations tested, will be presented in a subsequent article.

Materials and methods

Patient selection

One hundred male military inductees were randomly selected from the computer register at the Military Academy, Riyadh. Ninety-five attended and completed the examination. Mean age was 20.9 years (range, 19–25 years).

Questionnaire

By means of a bilingual questionnaire (Arabic and English), a history was obtained from each participant to assess the role of various possible factors related to oral health in general and to caries development and dental erosion in particular. The questionnaire included questions on types of food and beverages consumed, number of daily meals, and between-meal sweets and drinks. In addition, medication intake, general health conditions, symptoms of temporomandibular disorders (TMD), parafunctional and oral hygiene habits, subjective complaints, and the perceived need for treatment were recorded. A professional translator, who was trained in the use of the questionnaire, performed the interview with each of the participants, while the principal investigator (A.-K. Johansson) checked the completed questionnaire for accuracy at the end of each investigation day.

Clinical examination

All clinical investigations were performed by one investigator (A.-K. Johansson) and included recordings of severity of dental erosion, number of buccal cervical defects, visible plaque index (VPI), gingival bleeding index (GBI), DMFT and DMFS, and severity of fluorosis, in addition to a radiographic examination (four bitewing radiographs). Third molars were excluded from all examinations. Maxillary and mandibular alginate impressions were made in perforated stock trays and poured in diestone. Intraoral color transparencies (maxillary and mandibular occlusal, left and right lateral, frontal, palatal-anterior, and lingual-anterior views) were taken of all individuals. After GBI and VPI were recorded, meticulous cleaning of the teeth was performed, which included professional supragingival scaling and polishing with prophypaste. The teeth were carefully dried with an air syringe before assessment of fluorosis and erosion and photography.

Table 1. Ordinal scale used for grading severity of dental erosion on buccal and lingual surfaces of maxillary anterior teeth

Grade	Criteria
0	No visible changes. Developmental structures remain. Macro-morphology intact.
1	Smoothened enamel. Developmental structures have totally or partially vanished. Enamel surface is shiny, matt, irregular, 'melted', rounded or flat. Macro-morphology generally intact.
2	Enamel surface as described in grade 1. Macro-morphology clearly changed. Facetting or concavity formation within the enamel. No dentinal exposure.
3	Enamel surface as described in grades 1 and 2. Macro-morphology greatly changed (close to dentinal exposure of large surfaces). *or* Dentin surface exposed ≤1/3.
4	Enamel surface as described in grades 1, 2 and 3. Dentin surface exposed >1/3. *or* Pulp visible through the dentin.

Note: approximal erosion and presence of 'shoulder' should be recorded.

Assessment of dental erosion, cervical defects, cuppings, and incisal and occlusal wear

Grading of erosion was performed by using a modified version of an ordinal scale described by Eccles (22) (Table 1). The recordings were performed by one examiner (A.-K. Johansson) after a period of examiner training and calibration with two other investigators (A. Johansson and G. E. Carlsson). It became obvious that accurate assessment of the different grades of dental erosion was very difficult in the case of maxillary and mandibular premolars and molars and mandibular incisors. In addition, the incisal surfaces were excluded from the examination because of the difficulties in distinguishing between attritional and erosive influences on those surfaces. Therefore, only maxillary incisors and canines were graded and, furthermore, only the buccal and lingual surfaces. The final erosion score was

obtained from the combined assessments of clinical grading, study cast examination, and evaluation of intraoral transparencies. To assess the severity of erosion, a mean value index of all graded surfaces was calculated for each individual. The presence of 'shoulders' and/or approximal erosion was also assessed.

Cervical defects on the buccal surfaces were scored clinically for all the teeth in the dentition and recorded as the number of defects present in each individual. Apart from the requirement of clear demarcation, no distinction between different morphologies of the defects was made. Cuppings (concavities with a 'peephole' of dentin exposed, usually on the cusp tip) on all first molars were read from color transparencies and study casts and recorded as total number of affected teeth per individual.

Evaluation of occlusal and incisal wear was performed on a tooth-by-tooth basis on the study casts by two examiners (A.-K. Johansson and A. Johansson), by means of a previously used, analyzed, and described ordinal scale, which assigned a score to each degree of wear (17). Mean indices for the dentition and for the anterior (canines and incisors) and posterior (premolars and molars) teeth were calculated. In cases of disagreement, a final grade was mutually reached. The conditions of examiner calibration, the achievement of examiner concordance, and method reliability have been previously described (17). A few teeth that were fractured or had extensive restorations were excluded from evaluations of both erosion and wear.

Assessment of VPI, GBI, DMFT, DMFS, and fluorosis

VPI and GBI were recorded for each tooth on the buccal, mesiobuccal, and lingual surfaces in accordance with Ainamo & Bay (23). DMFT and DMFS were assessed in three ways: A) in accordance with WHO recommendations (24); B) including approximal caries detected in bitewing radiographs and extending radiographically to, or beyond, the amelodentinal junction; and C) including approximal caries detected in bitewing radiographs and extending ≥2/3 of the enamel thickness. For the second method of assessment (B), DMFT and DMFS were also divided into their components—that is, D (decayed), M (missing), F (filled), T (teeth), and S (surfaces). Severity of fluorosis was graded on a tooth-by-tooth basis, using a combined clinical and color transparency assessment, on the basis of the TF index (15).

Statistical methods

All statistical analyses were performed on an IBM Personal Computer, using the Statistical Package for Social Sciences (SPSS, Release 6).

Intraexaminer concordance in use of the scale for grading erosion was tested by the examiner (A.-K. Johansson), performing two successive blind assessments after an interval of 2 weeks, on each of the buccal and lingual surfaces of 120 teeth, corresponding to 230 buccal and lingual surfaces (10 surfaces ungradable) in 20 individuals on a randomly selected and ordered basis. Differences between variables were tested by using Student's *t* test for independent samples.

Table 2. Means ($\bar{x}$), standard deviations (s), and ranges (R) of beverage consumption in ml/week in the sample (n = 95); present consumption (present) and consumption before starting military service (past)

Type of drink	$\bar{x}$	s	R
Cola-type (regular)			
Present	4276	2221	0–10,065
Past	7175	3949	0–23,100
Other soft drinks (regular)			
Present	475	1179	0–7590
Past	186	1291	0–10,500
Fruit juice			
Present	1238	428	0–2550
Past	13	86	0–835
Tea (sweetened), present	5081	2376	0–11,550
American coffee (sweetened), present	44	230	0–1750
Arabic coffee (unsweetened), present	38	89	0–700

Results

Questionnaire

Dietary habits. All subjects ate three main meals per day, and owing to the military regimen, meals were also consistently uniform within the sample. Twelve per cent drank water during or just after meals, whereas the others drank sweetened tea (44%), soft drinks in combination with other beverages (23%), or sweetened tea in combination with water (21%). Eighteen per cent reported drinking only water as a between-meals drink; the rest mainly drank regular cola-type drinks (73%) and/or other regular soft drinks (9%). Weekly intake of sweets was reported by 54% as nil and by 46% as 1 or more. For the total sample, the mean number of sweet intakes was 3.2 per week (s = 4.57, R = 0–21). The weekly consumption of cola-type drinks, other soft drinks, fruit juice, tea, and coffee is shown in Table 2. It is noteworthy that the declared mean intake of cola-type drinks before starting military service was considerably higher (1.6 times) than that currently consumed. Weekly fruit consumption is shown in Table 3, the most frequently consumed item being dates (12.2 intakes/week).

Oral hygiene habits. Twenty-five per cent of the subjects reported not cleaning their teeth, 57% doing so occasionally (defined as ≥once/week for the past ≥1 year), and 18% once or more daily for the past ≥1 year. On average, those who reported cleaning had done so for the past 3.5 years (s = 2.32, R = 1–10). Of those

Table 3. Means ($\bar{x}$) and ranges of selected fruit and vegetable consumption in units or intakes/week within the sample (n = 95)

Item	$\bar{x}$	Range
Apples (no. of units)	2.5	0–7
Citrus fruits (no. of units)	3.2	0–14
Dates (no. of intakes)	12.2	0–77
Grapes (no. of intakes)	0.8	0–3
Olives (no. of intakes)	0.9	0–14
Pickles (no. of intakes)	0.04	0–3
Tomatoes (no. of units)	1.6	0–7

75% who reported cleaning their teeth, 24% used miswak ($\bar{x}$ = 2.6 years; s = 2.0, R = 1–8), 44% a toothbrush ($\bar{x}$ = 3.3 years; s = 2.5, R = 1–10), and 32% a combination of toothbrush and miswak ($\bar{x}$ = 4.4 years; s = 2.0, R = 2–8). Twenty-four per cent never used toothpaste, 59% used it occasionally (defined as ≥once/week), and 17% once or more daily (toothpaste used was always fluoride-containing). With regard to the technique used for cleaning the teeth, 43% reported 'no special technique', 36% 'up and down', 14% 'back and forward', and 7% a combination of 'up and down' and 'back and forward'.

General and oral health problems. The presence of systemic disease was only reported by one individual (dermatitis), and regular medicine consumption by four individuals. Thirty-two per cent reported dryness of the mouth, 21% bruxism, 61% occasional headache, and 39% occasional biting habits (nail-, pen-, nut-biting, and so forth) (Table 4). Dental-related problems were common within the sample, and 73% reported one or more symptoms. The single most common complaint was 'pain' (42%), followed by 'worn teeth' (39%), 'esthetics' (26%), 'tooth sensitivity' (22%), and 'difficulty in chewing' (9%) (one or more symptom could have been present in each individual).

Awareness. Seventy-two per cent of the subjects 'never or seldom visited a dentist', 11% 'visited a dentist at least every 5 years', and 17% 'visited a dentist once or more every year'. With regard to their awareness of the danger to oral health of intake of regular (sugar-containing) soft drinks, 35% were unaware of this; as to their awareness of the effect of diet soft drinks, 90% said they were not dangerous. Fruit juices and fruits were not considered to be harmful to oral health by 84% and 95%, respectively, and 2% stated that sweets were not harmful.

Table 4. Percentage frequency distributions of some of the responses to the questionnaire in relation to general and oral health (n = 95)

Do you, or have you suffer(ed) from:	No, %	Yes, occasionally, %	Yes, now, %
Any systemic disease?	99		1
Biting habits?	57	39	4
Bruxism?	79	15	6
Dryness of the mouth?	68		32
Frequent acid regurgitation/vomiting?	95		5
Headache?	37	61	2
Stomach problems?	90		10
TMD* problems?	90		10

* TMD = temporomandibular disorder.

Table 5. Means ($\bar{x}$), standard deviations (s), and ranges of the DMF indices assessed in accordance with WHO (A); including the radiographic diagnosis of approximal carious lesions extending to, or beyond, the amelodentinal junction (B); and including the radiographic diagnosis of approximal carious lesions extending ≥2/3 of the enamel thickness (C); and, using the first radiographic method of assessment (B), (ant) = including maxillary/mandibular canines and incisors; (post) = including maxillary/mandibular premolars and molars, within the sample (n = 95)

	$\bar{x}$	s	Range
DMFT (A)	9.7	5.6	0–24
DMFT (B)	10.0	5.4	0–24
DMFT (C)	10.5	5.5	0–24
DMFS (A)	17.5	13.5	0–73
DMFS (B)	18.3	13.9	0–75
DMFS (C)	19.4	14.1	0–75
DMFT (ant)	1.2	2.0	0–10
DMFS (ant)	1.9	3.9	0–21
DMFT (post)	8.9	4.3	0–16
DMFS (post)	16.5	11.5	0–54

Clinical examination

The mean number of teeth corresponded to 27, with a range of 19–28. On the basis of Angle's classification, 85% were class I, 8% class II, and 7% class III. Mean DMFT and DMFS without the aid of radiographs corresponded to 9.7 and 17.5, respectively. With the two radiographic assessments included, DMFT was 10.0 (B) and 10.5 (C), respectively, and DMFS 18.3 (B) and 19.4 (C), respectively (Table 5). For the first radiographic assessment (B), the values of the individual components of the DMFT were D = 7.7, M = 0.5, F = 1.8, and those of the DMFS were D = 12.6, M = 2.5, F = 3.2. Three individuals (3%) were caries-free without recourse to radiographs, but only one individual (1%) after radiographic assessment. Differences in both DMFT and DMFS between anterior and posterior teeth were numerically and statistically significant ($P < 0.001$) (Table 5).

Intraexaminer concordance (percentage agreement) for the examiner (A.-K. Johansson), in the scale used for grading the severity of erosion, between two successive blind assessments was 78%. A total of 551 maxillary anterior teeth were available for assessment of erosion, corresponding to 1083 surfaces (some surfaces were ungradeable because of the presence of restorations, cast inaccuracies, and so forth). The means of the erosion scores are shown in Table 6, and the distribution of the scores is illustrated in Figs. 1 and 2. Seventy-seven per cent of the maxillary incisors and

Table 6. Means ($\bar{x}$), standard deviations (s), and ranges of erosion index (mean of all graded surfaces of tooth numbers 13–23), number of first molars with cuppings, cervical defects, tooth wear indices, visible plaque index (VPI), and gingival index (GBI) within the sample (n = 95)

	$\bar{x}$	s	Range
Erosion	1.10	0.52	0–2.83
Cupping (first molars)	1.04	1.30	0–4
Cervical defects	0.73	1.61	0–9
Wear (dentition)	1.19	0.31	0.48–2.61
Wear (anterior teeth)	1.37	0.41	0.27–3.00
Wear (posterior teeth)	1.04	0.33	0.09–2.31
VPI (%)	47.3	23.0	6–100
GBI (%)	20.9	13.6	0–55

canines showed some degree of erosion. When grades 2–4 (which constitute a considerable degree of erosive wear) were combined, 28% of all the graded anterior teeth in the sample were affected (Fig. 2). Lingual surfaces were significantly more affected than the buccal ($P < 0.001$), whereas central incisors ($\bar{x}$ = 1.36; buccal + lingual) showed significantly more erosion than the laterals ($\bar{x}$ = 1.21; buccal + lingual) ($P < 0.001$) and the canines ($\bar{x}$ = 0.70; buccal + lingual) ($P < 0.001$); similarly, the laterals had significantly more erosion than the canines ($P < 0.001$). Thirteen teeth (2.4%) had cervical shoulders, and approximal erosion could confidently be established in one individual only.

The mean number of first molars with cuppings, buccal cervical defects, GBI and VPI, and dentition, anterior, and posterior wear indices are shown in Table 6. One or more cervical defects were found in 25% (n = 26) of the subjects. The distribution of the fluorosis scores is shown in Fig. 3, and according to the TF index

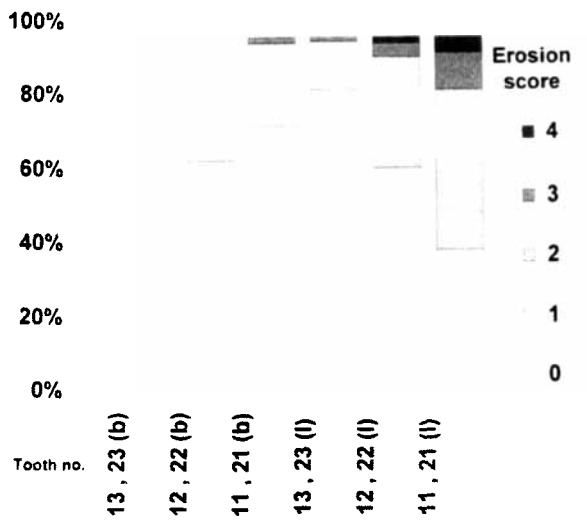


Fig. 1. Frequency distribution of erosion scores in maxillary incisors and canines (tooth numbers 13–23) on buccal (b) and lingual (l) surfaces (n = 1083 surfaces).

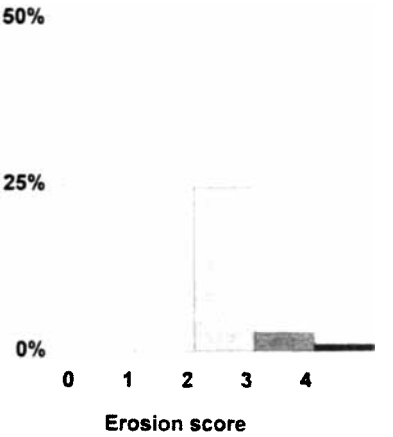


Fig. 2. Percentage frequency distribution of erosion scores in maxillary incisors and canines (n = 1083 surfaces).

(15), the premolars were most frequently affected, followed, in decreasing order, by the anterior teeth and molars. Severe fluorosis (scores 5–9) was found mainly in molars, followed, in decreasing severity, by the premolars and anterior teeth.

Discussion

The randomized nature of the sample selection and the good attendance (95%) enable us to draw some valid

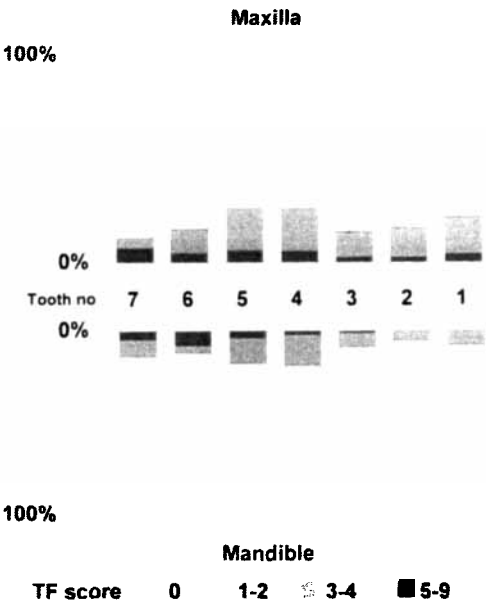


Fig. 3. Percentage frequency distribution of fluorosis scores on the basis of the TF index: 0 = no fluorosis; 1–2 = mild; 3–4 = moderate; 5–9 = severe.

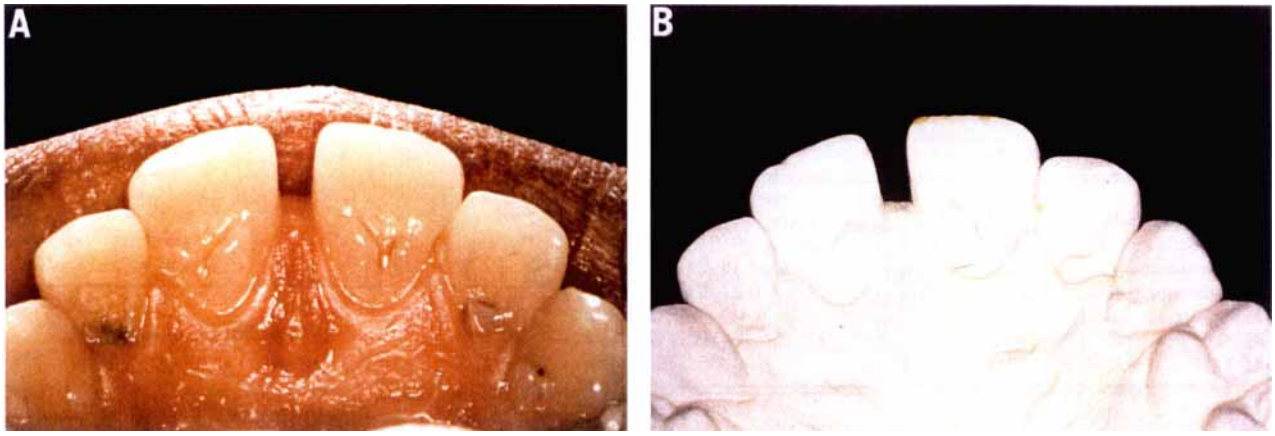


Fig. 4A. Examples of grade-0 erosion on all palatal surfaces of tooth numbers 13–23. 4B. Study cast of the same case. Note the obviously intact, virtually ideal palatal morphology.

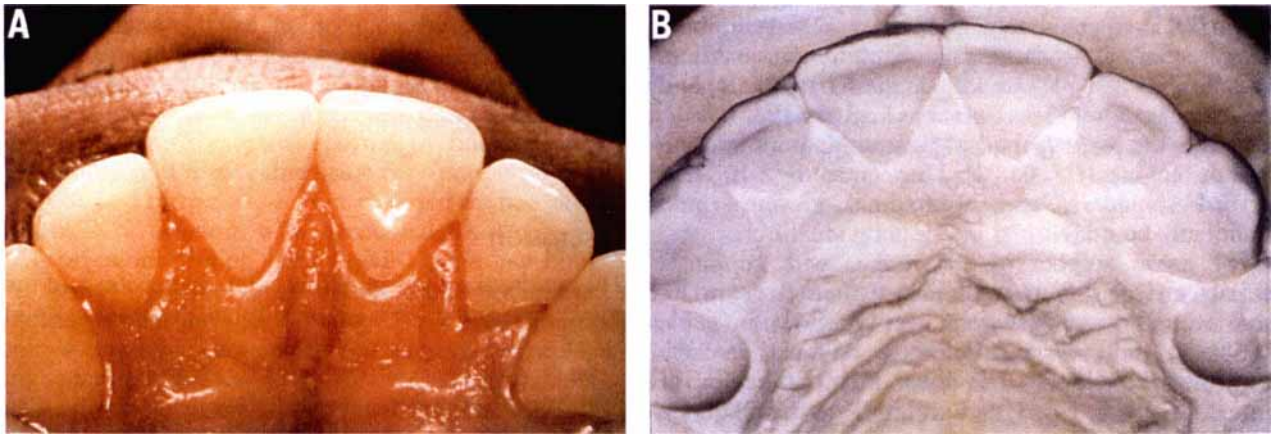


Fig. 5A. Examples of grade-2 erosion on all palatal surfaces of tooth numbers 13–23. 5B. Study cast of the same case. Note the changed 'washed-out' appearance of the entire palatal topography.

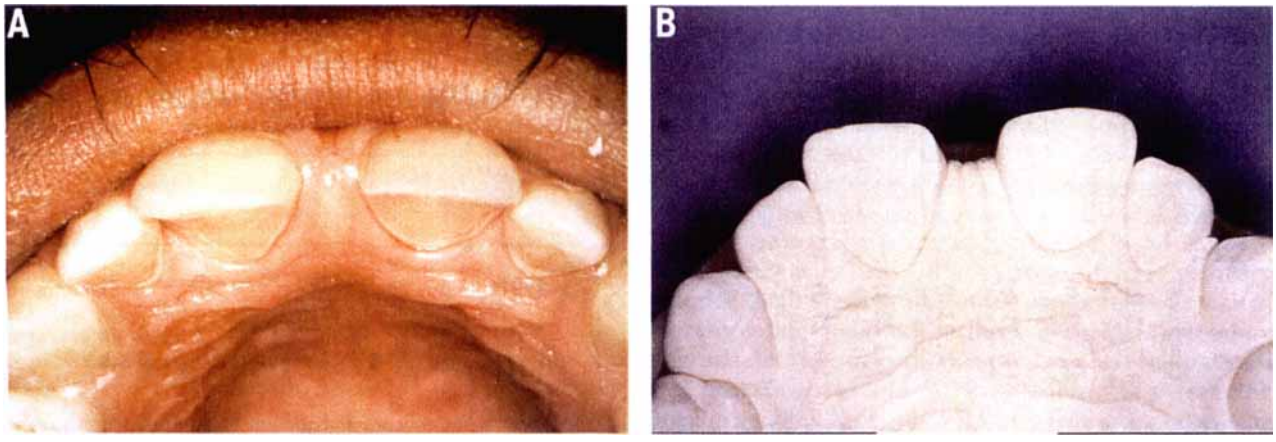
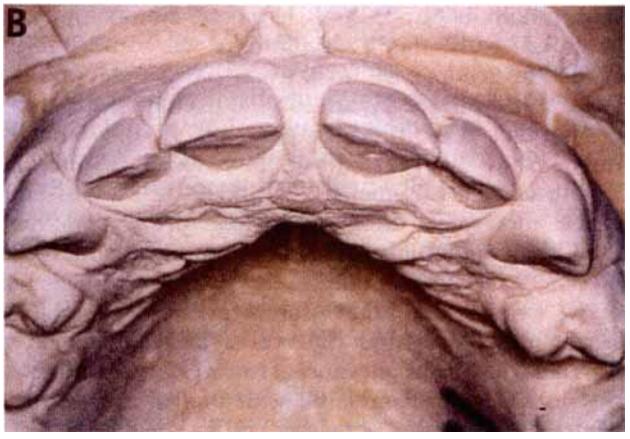


Fig. 6A. Examples of grade-1 erosion on palatal surfaces of tooth numbers 13 and 23, grade-2 on tooth number 22, and grade-3 on tooth numbers 12–21. Note the 'shoulder' on tooth numbers 12–22. 6B. Study cast of the same case.



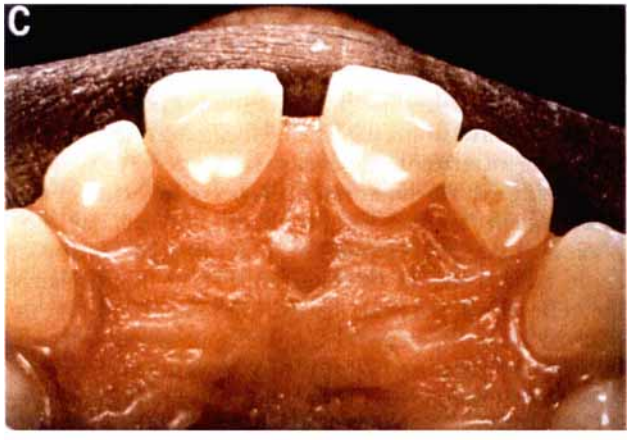


Fig. 7A. Examples of grade-2 erosion on palatal surfaces of tooth numbers 13 and 23, grade-3 on tooth number 22, and grade-4 on tooth numbers 12 21. 7B. Study cast of the same case. 7C. A more incisally directed view of the same case.

Fig. 8. Examples of grade-1 buccal erosion on tooth numbers 13, 12, 22, and 23 and grade-2 on tooth numbers 11 and 21.

conclusions, at least with regard to the present population sample. That the sample is representative of this age group within the general population cannot be definitely claimed, but they did represent a mix of the socioeconomic and educational scales. Nevertheless, it would be reasonable to assume that the young military inductees here are generally fit and healthy, as would be the case elsewhere, an assumption further supported by the general finding by the questionnaire of the absence of systemic diseases and use of medication in the sample investigated. Secondly, and their pre-military dietary habits notwithstanding, it would be reasonable to assume a more 'controlled' (or less 'uncontrolled') dietary intake than their nonmilitary counterparts, as is evidenced by the reduced cola-type drink intake since enrollment. In a study of attitudes of patients residing in the middle-eastern region, needs for improved oral hygiene measures and increased facilities for dental care were reported, whereas 'gum diseases' were highly prevalent among military personnel (25). A similar pattern is apparent in the present sample on the basis of several of the findings in the questionnaire: oral hygiene habits are generally inadequate, with dental attendance and awareness of oral health-promoting measures equally so. In the light of the aforementioned factors together with our clinical observations in the general population, the representativeness of the present sample of young adult Saudis is considered sufficient for general conclusions about their age group to be drawn.

With regard to the current number of daily meals taken and dietary items consumed, the dietary pattern of the sample could be considered to be 'normal'. Drinks consumed with the meal, just after and between meals consisted mainly of soft drinks or sweetened tea. Detailed analysis of soft drink consumption showed that the current average weekly intake of cola-type drinks was very high ($\bar{x}$ = 4.28 l per week), corresponding to a yearly intake of 223 l. Before starting military service, their estimated average yearly cola consumption was 7.18 l per week, corresponding to 373 l per year. If other soft drinks are included, the current consumption increased to 247 l, and pre-recruitment consumption to 383 l, a difference that highlights the potential for possible underestimation of erosive or other detrimental effects on oral health which might exist in the 'average'

young adult in Saudi Arabia. These figures can be compared with the consumptions of some other population groups: 12- to 24-year-old Swedes drank 52 l of soft drinks per year (26); the average per capita consumption of soft drinks per year in the United Kingdom was 104 l (27); 19- to 24-year-old men in the USA drank 139 l annually (28); and 9- to 18-year-old French adolescents drank 78 l of soft drinks per year (29). Of the numerous possible reasons for such marked differences in consumption levels between the present Saudi sample and the aforementioned examples, climatic differences and differences in public dietary awareness may be of relevance. However, the extremely hot Saudi climate, compared with that of most other countries, necessitates increased fluid intake. The lack of understanding of the harmful potential of soft drinks and the widespread affluence of the population may further explain the high consumption of such drinks. In addition, soft drinks are readily available and relatively cheap, and the convenient storage possibilities of bottled and canned beverages compared with fresh dairy or fruit products are important considerations.

Children with a high caries prevalence have been found to drink cola and other soft drinks more frequently than those with a low caries prevalence (30–32), and it has been stated 'that commonly used soft drinks, i.e. fruit juices, fruit drinks, carbonated beverages and sport drinks, have about the same "cariogenicity" as far as the total amount of sugars, acidity and the effect on plaque pH are concerned' (4). Consequently, the consumption of soft drinks seems to be a risk factor with regard to caries development, especially in the presence of predisposing salivary and microbial environments (3, 33). Further, the known caffeine content and potentially addictive capacity of cola-type drinks add another dimension to the sometimes excessive consumption, which is found even among very young individuals.

A striking finding from analysis of the questionnaire was the high proportion of individuals reporting not cleaning their teeth (25%). Among those who cleaned their teeth, the toothbrush was not the only cleaning device used: miswak (an indigenous wooden chewing stick) has, by tradition and religious teaching, been used by Arabs for centuries. Miswak is also used in several countries in the Indian subcontinent and in Africa, and reports of its antimicrobial properties have appeared (34–36). Nevertheless, the absence of systematic and regular oral hygiene measures, in addition to incorrect technique in many of the subjects, explains the high GBI and VPI indices (37).

The frequent clinical occurrence in this young military population of dental erosion, in addition to other types of wear, was an important result of the investigation. Distinguishing among wear caused by abrasion, erosion, and attrition is difficult due to their frequent concurrence and superimposition, which necessitated the use of two scales for recording tooth wear: a commonly used scale for grading occlusal and incisal wear (without regard to type of wear, and applicable to the whole dentition) (38) and a modified version of a previously described scale for grading erosion on buccal and palatal surfaces (Table 1) (22). Maxillary anterior teeth were clinically found to be common sites of, and most severely affected by, erosive wear, making their accurate and reliable assessment for erosion possible. Other teeth in the dentition were not as reliably gradable, because they were not so severely affected. In addition, morphologic complexities and photographic and cast qualities are factors limiting the assessment of erosion (and other types of wear) in general, and particularly so for posterior teeth. This was why the assessment of erosion was confined to the maxillary anterior teeth. In the clinical assessment of erosion, the standard mouth mirror was difficult to use. The mirror used for occlusal views in intraoral photography, together with a good operating light, was therefore utilized, which facilitated the clinical recording of erosion. The casts were very valuable in visualizing three-dimensional aspects of changes in morphologic features: both buccal and palatal morphology and any change in buccolingual dimension could by this means be detected (Figs. 4–8). Similarly, the effects of camera angle and lighting on the photographic image, and the angle at which a cast is viewed, can significantly affect the appearance and give a further dimension to the overall assessment (Fig. 7A–C). The erosion in this sample was most severe for the central incisors, followed by the lateral incisors and the canines, with the lingual surfaces mostly affected (Fig. 1). Discussion of the causes of the severe erosion observed is not within the scope of this article, and whereas its negative implications are obvious, possible associations will be addressed in a subsequent paper with details of the statistical analyses performed.

Using identical recording techniques, the degree of tooth wear graded from casts in this sample was lower than that reported in a similarly aged Saudi dental student population but higher than in an Indian dental student population (17, 39). Wear of anterior teeth was higher than that of posterior teeth, which is the commonly found wear pattern in contemporary populations (17). The reasons for the lower wear experience in the present Saudi military sample than in its dental student equivalent are not obvious, although it may be speculated that educational, social, dietary, and geographic backgrounds could be relevant. However, some aspects are noteworthy with regard to the difference observed: i) the high degree of erosive wear in this sample may 'mask' some of the features applied in the wear scale, thus potentially underscoring wear; ii) given that the data collection for the student study was carried out only 8 years earlier, the extremely rapid socioeconomic development that Saudi Arabia has undergone may support the old adage with regard to tooth wear that changing lifestyles accompanying urbaniza-

tion or cultural development reduce the potential for wear (40–42); and iii) on the assumption that the dental student sample is similarly prone to erosive wear by virtue of comparable ages and environments for them and the present inductees, the additional factor of a greater likelihood of regular toothbrushing and use of toothpaste among the former group may have aggravated the severity of wear they experienced (43).

Cervical defects were found in 25% of the sample with at least one tooth affected, which greatly exceeds the 7.7% reported in a 26- to 30-year-old Swiss population (44). In addition to 'toothbrush abrasion' and cervical erosion as possible causes of such defects, it has been suggested that heavy stressing of the teeth (for example, heavy chewing or bruxism) will result in strain microfractures along the buccal cementoenamel junction, possibly making the area more prone to destruction (45, 46). In this respect, biting habits and bruxism were frequently reported in this sample, which could, aside from the influence of erosion, further explain the high prevalence of cervical defects. Toothbrushing and the use of toothpaste were generally minimal and would therefore not be a major etiologic factor in this sample. Consequently, the multifactorial etiology of cervical defects would seem to be a reality (47, 48).

The caries prevalence in this sample (DMFT, $\bar{x}$ = 10.0; DMFS, $\bar{x}$ = 18.3) is considerably higher than in similarly aged Western samples. For example, in Australian 20- to 24-year-old recruits the mean DMFT was 6.9 (49), and in Danish 20-year-old military conscripts the mean FS (filled surfaces) was 8.7 in 1991 (50) (in this study, the FS index corresponded closely to the DMFS). In a recent study of an 18- to 19-year-old mixed Swedish sample, the DFS was 8.9 (51), which, again, is far exceeded by that of the present Saudi inductees (DFS = 15.8). In a 1977 study, in which caries status was reported in 217 Saudi naval recruits of an age similar to that of the present sample, the mean DMFT was 3.7, which was significantly lower than that of similarly aged US naval recruits (DMFT, $\bar{x}$ = 11.3) (52). The pattern seems to have been reversed over the past 18 years, with the Saudi inductees today having a higher caries prevalence than their Western counterparts. The paucity of epidemiologic surveys of caries prevalence in Saudi Arabia makes comparisons difficult. In the only relevant report to date, the DMFT in the 15- to 24-year-old group ranged from 5.5 to 7.0 for rural and urban locations, respectively (14). Given that no gender distinction was made in this age group in the report cited (14), the DMFT is considerably lower than in the present sample. It has been stated that the caries incidence in Saudi Arabia would probably increase (14), a statement that this study seems to firmly corroborate in view of the threefold higher caries prevalence in the present 1995 military sample compared with the 1977 naval one (52), and a doubling of DMFT compared with the 1991 mixed survey (14); whereas absolute comparison with the latter study is not feasible in view of the gender mix, it would be reasonable to note the clear trend.

The apparent treatment need as reflected by the number of individuals with complaints of wear, pain, sensitivity, impaired esthetics, and difficulty in chewing was very high. In addition, their extremely high level of soft-drink consumption, their incognizance of its dangers, indifferent oral hygiene habits, irregular or no dental care, and the large number of untreated carious cavities must necessarily lead to grave consequences for oral health, consequences that the clinical findings in this study have to an alarming extent confirmed.

In conclusion, owing to the high prevalences of dental erosion and fluorosis and rapidly increasing caries prevalence reported here, the need for serious recognition of their implications in the planning of future dental health care programs is stressed.

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