Mehaničko i kemijsko trošenje zuba - pregled

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Sažetak

Dan je pregled današnjih spoznaja o mehaničkom i kemijskom trošenju zuba i dentalnih ispuna te o povezanosti atricijsko-abrazijsko-erozijskih djelovanja u svjetlu tribologijske znanosti i naših kliničkih iskustava. Navedeni su unutarnji i vanjski uzroci nastalih defekata, njihov odnos prema kliničkoj slici s posebnim osvrtom na kliničke manifestacije subkliničkih erozija cakline i dentina. Navedeni su neki od indeksa za kliničku klasifikaciju potrošenoga zuba i nove tehnologije koje se rabe u znanstvenom istraživanju te problematike.

Ključne riječi: *trošenje zuba, abrazija, atricija, erozija*

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U dentalnom su se nazivlju pod trošenjem zuba podrazumijeva postupni nastanak zubnoga tkiva i dentalnih ispuna u sljedećim slučajevima: međusobnim dodirom zuba kod funkcijskih i parafunkcijskih kretanja čeljusti, abrazivnim djelovanjem raznih čestica ili tvrdih predmeta neovisno o funkciji i kemijskim učinkom kisele hrane ili pića, aerosola ili regurgitiranoga želučanog sadržaja. Prema tome, u ustima se kod trošenja zuba i dentalnih ispuna događaju procesi abrazije, atricije, erozije, adhezije, korozije i zamora materijala. Ti se procesi prožimaju i u konačnici dovode do nestanka zubnih tkiva i/ili dentalnih ispuna (1).

U dentalnoj medicini to nazivlje ne uključuje gubitak tkiva nastao mikrobnim djelovanjem na zube; tom problematikom bavi se kariesologija.

Atricija zuba

Pindborg (2) definira atriciju kao tip trošenja zuba na mjestima izravnoga dodira zubnih ploha, a Lambrecht (3) taj pojam primjenjuje i za trošenje ispuna na mjestima okluzijskoga dodira. Atricija se očituje nestajanjem vrškova kvržica ili incizalnih rubova kao posljedica trenja faseta na okluzalnim ili palatinalnim površinama zuba. Proces trošenja može doprijeti do dentina, koji se tada brzo troši. Trenje interproksimalnih dodira također dovodi do redukcije aproksimalnih dijelova zuba tipa atricije pretvarajući s vremenom dodirne točke u dodiirne plohe (interproksimalna abrazija).

Abrazija zuba

Abrazija zuba definirana je kao trošenje zubnoga tkiva neovisno o funkciji žvačnoga sustava, a nastaje trenjem neke strane tvari o zub (2). Trošenje toga tipa nastaje trenjem zubne četkice i paste po zubnoj površini (abrazija zubnog četkanja) (4), kvačica od zubnih proteza i ortodontskih naprava (5), raznim navikama, kao držanje lule u zubima (6), pušenje (7) grickanje olovke, čačkalice ili nekoga dru-

gog predmeta (loše navike) (8), ljuštenje koštica zubima (9) ili su posljedica ritualnih obreda ili životnih navika primitivnih naroda Azije, Afrike i Amerike (2).

Abrazije zuba mogu biti u vezi s nekim zanimanjima, kao kod glazbenika na nekim puhačkim glazbalima (klarinet) (8), ili loših navika pri radu, kao što je grickanje ili prekidanje konca zubima u krojačica (10), rada u kamenolomu (11) ili nekih zanimanja kod kojih se u aerosolu mogu naći čestice abraziva (12).

Abradirani dio zuba može imati razne oblike ovisno o predmetu koji ga je uzrokovao, a stupanj istrošenosti zuba ovisi o tome koliko dugo je zub izložen takvu utjecaju (10) i kutu pod kojim sila djeluje na caklinske prizme (13).

Pojam abrazije dentalnih materijala odnosi se na trošenje zubnih ispuna na dijelovima izvan dodirnih ploha. Očituje se nestajanjem ispuna cijelom površinom, nakon čega ostaju ogoljeni rubovi cakline, što se najviše opaža kod kompozita na distalnim zubima (14).

Mehaničko trošenje zuba posljedica je funkcije žvačnoga sustava, a događa se tijekom cijeloga života. Najčešće se radi o kombinaciji atricije i abrazije koja je uzrokom gubitka tvrdih dentalnih tkiva mijenjajući morfologiju pojedinih zuba.

Danas se zna da na uzroke i stupanj trošenja zuba uvelike utječu količina i kakvoća abraziva u hrani (14), salivacija, dob (15), spol i radna okolina (3,12,16,17), funkcijska i parafunkcijska zbivanja, te način mendibularnih ekskurzija (18,19). U osamnaestmjesečnom ispitivanju opaženo je da su se zubi interkaninskog sektora brže trošili od zuba u distalnim regijama te da su bruksizam (19) i regurgitacija želučanog sadržaja znatno utjecali na jače trošenje zuba (20,21). Zatim je opaženo da su se zubi donje čeljusti više trošili od zuba gornje čeljusti, te da su se zubi interkaninske regije jače trošili u muškaraca nego u žena (17,22). Kaidonis (19), međutim, u ispitivanju trošenja distalnih zuba nije našao razlike među spolovima. Opaženo je da količina abraziva u hrani više pridonosi trošenju zuba nego konzistencija same hrane (22), te da abrazija zuba raste s godinama života (23).

Kod ispitivanja gubitka tvrdih zubnih tkiva nastalih mehaničkim djelovanjem sve se više rabi naziv "trošenje zuba", a njime se podrazumijeva zajedničko djelovanje abrazije i atricije.

Sveobuhvatna ispitivanja tih zbivanja pokazala su da se mahanizmi abrazije i atricije događaju usporedno kroz cijeli životni vijek, ali da se u konačnici ne mogu ispitivati odvojeno od procesa erozije, jer je kiselinsko djelovanje na zube pojava koja također prati zube dokle god su u ustima. U kliničkoj slici najčešće prevladava jedan tip trošenja zuba, pa on prevladava u postavljanju dijagnoze. Pritom treba imati na umu da je kod prikupljanja anamnestičkih i drugih podataka važno doznati sve moguće uzroke trošenja zuba, jer je to jedini ispravan put da se planira i izvede odgovarajuća rehabilitacija ili da se provede zadovoljavajuća prevencija.

Erozija zuba

Erozija zubnoga tkiva po svojoj je naravi kemijski proces. On je obilježen gubitkom zubne površine zbog djelovanja kiselina koje nisu bakterijskog izvora (2,24). Erozija može potjecati od kiselina probavnoga trakta (erozije unutarnjeg podrijetla) ili prehrane i okoline (erozije vanjskog podrijetla). Regrutacijske erozije smještene su na palatinalnim plohama zuba, a posljedica su bolesti probavnoga trakta s gastričnim refluksom, bulimijom nervozom, kroničnim alkoholizmom i čestim povraćanjem bilo koje etiologije, primjerice, povraćanja u trudnoći (21). Ponekad su palatinalne erozije jedini ili prvi znak subkliničkog refluksa. Zbog toga ih stomatolog treba opaziti i usmjeriti pacijenta na gastroenterološku obradu (21,25). Kiseli sadržaj kod endogenih erozija zadržava se između jezičnih papila i u gingivnom sulkusu, a kod egzogenih u jamicama, fisurama i interdentalnim prostorima zuba.

Erozije vanjskoga podrijetla potječu od kisele hrane (voće, kiseli začini) ili pića (26), poput Coca-Cole i voćnih sokova, među kojima je najagresivnija limunska kiselina koja, vezujući se na kalcij cakline i dentina, stvara komplekse topljivih kalcijevih citrata (2). Utjecaj narančina soka na dentin u ispitivanju SEM se je očitovao skidanjem ingredijenata zubne paste, skidanjem *smear layer-a* i otvaranjem dentinskih tubula s mikromorfološkom slikom koja odgovara djelovanju fosforne kiseline (27).

Profesionalno uvjetovane erozije nastaju djelovanjem kiselina na zube kao posljedica nekog tehnološkog procesa (industrijske erozije) u kojemu

radnici dolaze u doticaj s kiselinom, najčešće u obliku aerosola. Navode se solna, formična, pikrična, sumporna kiselina i druge kiseline, te njihovi kiseli spojevi.

U našim su ispitivanjima godine 1996. Njemirovskij i sur. (28) našli opsežne erozije zuba u tvornici akumulatora otvorenog tipa. Danas više nisu tako česte klinički manifestne industrijske erozije, jer se napredovanjem tehnologija uvode zatvoreni sustavi industrijske proizvodnje s opasnim tvarima (29). Ne nalazimo više ni erozije prouzročene kiselim medikamentima, kao što je prije bio slučaj s uporabom razrijeđene solne kiseline ili otopljenih željeznih pripravaka s kiselim pH vrijednostima, jer je farmaceutska industrija novim tehnologijama kapsuliranih pripravaka zaštitila usnu šupljinu. Za razliku od toga, danas se opaža velik porast erozija kojima je uzrok masovno uživanje Coca-Cole i voćnih napitaka, prehrambena navika današnjeg života.

Klinička slika erozija je različita. U početku caklina gubi sjaj i nastaje izrazita glatkoća zubne površine. Poslije nastaju oštećenja na glatkim plohama u obliku generaliziranoga ploštimičnog iščezavanja cakline ili oštećenja cakline bubrežastoga, diskoidnog ili klinastog oblika, a na incizalnim bridovima ili okluzalnim kvržicama u obliku malih ograničenih defekata (30). Proces demineralizacije proporcionalan je putu unosa i vremenskom djelovanju kiseline, količini, vrsti i koncentraciji kiseline. Kod dugotrajnoga djelovanja nastaje difuzno nestajanje cakline na velikom broju zuba s ogoljenim i preosjetljivim dentinom. Iako je koncentracija vodikovih iona u mediju najvažniji čimbenik erozije vitalnih zubnih tkiva, novije spoznaje iz te problematike pokazuju da i druge tvari utječu na proces demineralizacije. Ustanovljeno je (31) da topikalna fluoridacija inhibira početak erozije, a da postojanje kolagenaze u mediju (32) pojačava demineralizaciju. Ovdje se radi o uzajamnom napadu na organsku i anorgansku supstanciju. Degradacijom kolagena, osobito kod uznapredovalih erozija, potkopavaju se mineralizirani dijelovi tkiva, odnosno polje djelovanja na organski dio, što ubrzava proces nestajanja zubne supstancije. Doda li se tome učinak trenja po zubu žvačnom muskulaturom, jezikom i usnama, abrazivno djelovanje hrane i zubno četkanje, dolazimo do spoznaje da se kod erozije odvijaju višeuzročni mehanizmi erozivnoga trošenja zuba (tribologija).

Dinamične promjene unutar naše radne i životne sredine, drugačije prehrambene navike i sve brojniji podatci o biokmijskim mehanizmima erozije doveli su nas u okolnost da, osim studija klasičnih slika erozija, usmjerimo pozornost na stanja koja bismo mogli nazvati subkliničkim erozijama. Kao primjer predisponirajućih čimbenika za takva stanja kod unutarnjih erozija mogli bismo navesti subkliničke oblike gastrointestinalnog trakta (tiha regurgitacija), kod industrijskih erozija količinu kiselinskih para u radnoj atmosferi koja je u granicama dopuštenih standarda, a kod dijetalno uzrokovanih erozija često uživanje voćnih napitaka, što je danas uvriježena životna navika. To su stanja koje čine vanjsku ili unutarnju sredinu potencijalno opasnom za visokomineralizirana zubna tkiva. Ona remete mehanizme remineralizacije cakline, koja se smatra prirodnim mehanizmom zaštite zuba, i time mogu poremetiti homeostazu (biološku ravnotežu) oralnoga sustava. Hoće li se i koliko će se poremetiti ta ravnoteža ovisi, osim nabrojanog, o količini i sastavu sline, njezinu puferskom kapacitetu, gustoći mineralizacije caklina (13), habitusu žvačnog sustava te o prehramebnim i higijenskim navikama.Ovo posljednje zato što je atricijsko-abrazijska sastavnica neizbježan događaj u uklanjanju potkopanih mikrostrukturnih dijelova mineraliziranoga tkiva. Kliničke manifestacije takva stanja očituju se na razne načine. U osoba s visokim standardima oralno-higijenskih navika poremećena homeostaza očitovati će se u nastanku idiopatskih erozija ili tek s preosjetljivošću zuba na termičke, kemijske i mehaničke podražaje, a u osoba s niskim standardima oralne higijene očitovat će se većim porastom karijesa u usporedbi s ostalom populacijom iste sredine (29). U prvom slučaju, zbog funkcijske aktivnosti žvačnoga sustava i četkanja zuba, kojom radnjom se ljuške površinske i podpovršinske mikrolezije, ostaju glatki, erodirani defekti cakline i/ili ogoljen, kondicioniran i preosjetljiv dentin. U drugom slučaju izostaju mehanizmi ravnoteže između cakline i kariesogene mikroflore, koja na tako manje vrijednoj caklini mnogo lakše probija fizičku barijeru zuba i dovodi do karijesne kavitacije cakline. Osim navedenoga, Bevenius i sur. (33) drže da defekti u obliku cervikalnih erozija mogu nastati isključivo kao posljedica okluzijskoga stresa kod nepravilnih lateralnih kretanja čeljusti.

Erozije dentalnih ispuna u svojoj su biti kombinacija više tipova trošenja materijala: erozije, korozije i atricije (*tribochemical wear*). Najprije nastaje

erozivno potkopavanje čestica materijala tekućim medijem određene koncentracije vodikovih iona (pH). Nakon toga slijedi kemijska degradacija materijala (korozija) i uklanjanje erodiranoga materijala trenjem ploha s abrazivnom komponentom ili bez nje (atricija/abrazija) (1). Klinički izgled takva stanja očituje se nestankom dijela ispuna s izbočenim rubovima cakline.

Metode ispitivanja

Proučavanjem abrazije, atricije i erozije, to jest trošenja zuba, danas se temelje na kliničkim, laboratorijskim i elektroničkim istraživanjima. Najraniji nalazi bili su deskriptivni i oni su postali temeljem kasnijih kliničkih ispitivanja, koja su i danas neizbježna bez obzira na dozu subjektivnosti koju u sebi nose. Najčešći indeksi koji se danas rabe u kliničkim ispitivanjima jesu indeksi Smitha i Knighta (34). Njima se gubitak tkiva na svim plohama obilježava deskriptivno i mjeri u milimetrima, a u istraživanjima nekih autora doživljavaju tek neznatne varijacije, što ovisi o problematici kojom se bave (10,18). Noviji nalazi nadopunjuju se anketnim listovima, kako bi se otkrili svi mogući etiološki čimbenici (aerosol, regurgitacija, povraćanje, glavobolje, škripanje zubima, loše navike, prehrana, zanimanje i sl.) koji bi mogli utjecati na trošenje zuba (20). Pokazalo se je, naime, da defekti raznih etiologija mogu imati iste ili veoma slične oblike.

Praćenje funkcijskoga trošenja zuba u istih osoba zahtijeva duže razdoblje. U tu se svrhu rabe otisci zuba i fotografije (18,20) te se na njima mjere promjene na nastalim fasetama. U ispitivanju trošenja zuba u vezi s abrazivima u hrani u razdoblju kraćem od nekoliko tjedana Teaford (35) prati ogrebotine na fasetama majmunskih zuba s pomoću SEM-a i mikrofotografija. Općenito, SEM se rabi u mnogim slučajevima gdje za to postoji prigoda (2, 5, 13, 27). Lambert (3) u svojim istraživanjima upotrebljava računaliziranu trodimenzijsku tehniku mjerenja potrošenoga dijela zuba. Isto čini i Viasis (5) za usporedbu trošenja okluzijskih ploha prije i nakon pokusa, a kvantitativne promjene (stupanj caklinskoga trošenja) proučava vizualno s pomoću računalne grafike i SEM-a. Akamatsu (36) u ispitivanju noćnoga bruksizma osim elektromiografije (za funkciju masetera) rabi i magnetski osjetnik za obilježavanje položaja čeljusti za vrijeme bruksizma.

Kako *in vivo* testovi abrazije četkanjem zuba nisu uspješno standardizirani, rabe se razni modeli laboratorijskog ispitivanja, među kojima se je veoma pouzdanom pokazala metoda s radioaktivnim markerima (4). Odnos dentinskih tubulusa i ingredijenata zubnih pasta te erozivni učinak voćnoga soka na dentin Absi (27) je ispitivao s pomoću SEM-a. Pindborg (2) prikazuje površinske i podpovršinske mikroerozije s pomoću mikroradiografije, a kod klinički vidljivih industrijskih erozija kategorizira defekte u četiri stupnja, počevši sa zamućenom caklinom (0. stupanj) do stanja u kojemu zub nestaje sve do pulpe (3. stupanj). Za test fizičke otpornosti cakline i dentina te kvantitativne varijacije mikrotvrdoće erodiranoga minerallizirano tkiva Boyd (13) se služi metodom zračnoga poliranja vodom i natrijevim bikarbonatom kao abrazivom, pod kontrolom stereobinokularnoga mikroskopa i SEM-a.

Iz navedenoga se vidi da se u ispitivanju trošenja zuba znanstvenici više ne zadovoljavaju klasičnim metodama mjerenja, da se daje velika važnost etiologiji nastalih defekata te tribologijskim mehanizmima trošenja tkiva i dentalnih materijala.

Fiziološko trošenje zuba danas se mjeri u mikrometrima, jer je mehaničko trošenje zuba kao rezultat načina prehrane sporije, a znanja iz erozije se produbljuju. Zato se danas poznate metode nastoje kvalitetno standardizirati, a uvođenjem novih tehnoligija u to polje znanosti promicati metode rada koje bi pridonijele otkrivanju nepoznatih pojedinosti iz te za stomatološku medicinu veoma važne problematike.

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Mechanical and Chemical Tooth Wear - a Review

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Summary

A review is given of the present state of art on mechanical and chemical wearing away of teeth and dental fillings, and on the relationship between the effects of attrition, abrasion and erosion in the light of tribology and our own clinical experience. Endogenous and exogenous causes of defects, as well as their relation with the clinical picture are presented, with particular reference to clinical manifestation of subclinical enamel and dentin erosions. Some indices for clinical classification of tooth wear and new relevant research technologies are described.

Key words: *tooth wear, abrasion, attrition, erosion*

In dental terminology, tooth wear refers to the loss of dental tissue and dental fillings in the following conditions: mutual tooth friction on functional and parafunctional mandibular movement, abrasive action of various particles or hard objects regardless of the function, and chemical effects of acidic food or drink, aerosol or regurgitated gastric content. Thus, the wear of teeth and dental fillings includes the processes of abrasion, attrition, erosion, adhesion, corrosion, and wear of the material. A combination of all these eventually leads to the loss of dental tissue and/or dental fillings (1).

In dental medicine, this terminology does not include tissue loss due to microbial effect on the teeth, as this issue is tackled by cariology.

Tooth attrition

Pindborg (2) defines attrition as a type of tooth wear at the sites of direct contact of tooth surfaces, and Lambrecht (3) applies the term also to the wear of fillings at the sites of occlusal contact. Attrition manifests by the loss of the tips of the papillae or incisal edges consequential to facet friction on occlusal or palatal surface of the teeth. The process of wear may penetrate to the dentin, which is then exposed to fast wear. The interproximal contact friction may also cause an attrition-like reduction of approximal segments of the teeth, with time transforming the contact points into contact surfaces (interproximal abrasion).

Tooth abrasion

Dental abrasion is defined as the loss of tooth substance irrespective of the masticatory system function, caused by friction of a foreign material against the tooth (2). This type of wearing away is produced by the friction of tooth brush and tooth paste against the tooth surface (brushing abrasion) (4),

dental prosthesis clamps and orthodontic appliances (5), various habit patterns such as holding a pipe with the teeth (6), smoking (7), biting a pencil, toothpick or some other object (bad habits) (8), shelling stone-fruit with teeth (9), etc. It may also be consequential to some rituals or customs in primitive peoples from Asia, Africa and America (2).

Tooth abrasion may be associated with occupation, e.g., playing some wind instruments, e.g., clarinet (8), or with some bad habits while working, e.g., biting or cutting a string by teeth in tailors (10), work in stone-pits (11) or in the presence of aerosol containing abrasive particles (12).

The abraded part of the tooth may be variedly shaped, depending on the causative agent, while the degree of abrasion depends on the length of tooth exposure (10) and angle at which the power acts upon the enamel prisms (13).

The term dental substance abrasion refers to the wearing away of dental fillings in the segments beyond the contact surfaces. It manifests by the loss of filling over the entire surface, leaving the edges of the enamel exposed, which is most pronounced in composites on distal teeth (14).

Mechanical tooth wear occurs as a consequence of the masticatory system function throughout one's life. It is usually a combination of attrition and abrasion that leads to the loss of hard dental tissue, thus changing the morphology of individual teeth.

At present, the causes and degree of tooth wear are known to be greatly influenced by the amount and quality of food abrasives (14), salivation, age (15), sex and working environment (3,12,16,17), functional and parafunctional events, and mode of mandibular excursions (18,19). In an 18-month study, the teeth of the intercanine sector were found to wear away at a faster rate than those in distal regions, while the severity of tooth wear was found to increase with bruxism (19) and gastric content regurgitation (20,21). Furthermore, mandibular teeth were observed to undergo a higher rate of tooth wear than the maxillary teeth, whereas the teeth of the intercanine region wore away at a higher rate in men than in women (17,22). However, in a study of distal tooth wear Kaidonis (19) found no sex difference. The amount of dietary abrasives was observed to contribute to tooth wear more than food consistency (22). Tooth abrasion was also found to increase with age (23).

In the study of hard tooth substance loss due to mechanical action, the term "tooth wear" referring to the joint action of abrasion and attrition, has been ever more used. Comprehensive studies of these events have shown the mechanisms of abrasion and attrition to occur in parallel, and to exert their action on the teeth throughout one's life, as well as that they cannot be observed apart from the process of erosion, because the acidic effect on the teeth is also a phenomenon accompanying the teeth for as long as they are retained in the mouth cavity. The clinical picture is usually predominated by one type of tooth wear, which then prevails when making the diagnosis. Therefore, when taking history and other data, care should be exercised to obtain data on all possible causes of tooth wear, as this is the only way to ensure appropriate planning and rehabilitation or satisfactory prevention.

Tooth erosion

Dental tissue erosion is by its nature a chemical process characterized by the loss of tooth surface due to the action of acids of non-bacterial origin (2,24). It may arise from digestive tract acids (endogenous erosion) or from diet and environment (exogenous erosion). Regurgitation erosions are located on the palatal surfaces of the teeth, and are consequential to the digestive tract diseases with gastric reflux, bulimia nervosa, chronic alcoholism, and frequent vomiting of any etiology, e.g., vomiting of pregnancy (21). Palatine erosions may occasionally be the only or first sign of subclinical reflux, therefore they should be timely recognized by the dentist and the patient should be referred to gastroenterologic examination (21,25). In endogenous erosions, the acidic content is retained between the lingual papillae and within the gingival sulcus, whereas in exogenous erosions it is retained in the pits, fissures and interdental spaces of the teeth. Exogenous erosions originate from acidic foods (fruit, acidic spices) or drinks (26), e.g., Coca Cola and juice, among which citric acid is most aggressive, binding to the enamel and dentin calcium, and forming complexes of soluble calcium citrates (2). In the SEM study, the effect of orange juice on dentin manifested as the removal of tooth paste ingredients and smear layer, and opening of dentin tubules with

a micromorphological picture corresponding to the effect of phosphoric acid (27).

Occupational erosions occur due to the effect of acids on the teeth consequential to a technologic process (industry erosions), where the workers come in contact with acids, usually in the form of aerosol. Thus, hydrochloric acid, formic acid, picric acid, sulfuric acid, and other acids and their acidic compounds have been described.

In a study performed in 1966 Njemirovskij et al. (28) found extensive tooth erosions in subjects working in an open battery plant. Since then, however, with technologic advances and introduction of closed systems in the industrial production involving hazardous substances, manifest occupational erosions have become less common (29). Erosions due to acidic medicaments, such as those previously caused by the use of diluted hydrochloric acid, and dissolved iron preparations with acidic pH values, are no longer encountered, since new technologies of encapsulated preparations used in the manufacture of pharmaceuticals have provided due protection of the oral cavity. On the other hand, however, a high increase in erosions due to the large-scale use of Coca Cola and fruit juice, which have become a constituent part of daily life, has recently been recorded.

Tooth erosion may present a variable clinical picture. Initially, the glossy appearance of enamel and tooth surface smoothness are lost. This is followed by damage to smooth surfaces, in the form of generalized, flat wearing away of the enamel or reniform, discoid or cuneiform enamel lesions, and small, restricted defects on the incisal edges or occlusal papillae (30). The process of demineralization is proportional to the route of intake and temporal action, amount, type and concentration of the acid. Prolonged action leads to diffuse wearing away of the enamel on a great number of teeth, with exposed and hypersensitive dentin. Although the concentration of hydrogen ions in a medium is the most important factor of erosion of vital dental tissues, recent concepts on the issue have shown that other substances are also involved in the process of demineralization. Topical fluoridation has been reported to inhibit the onset of erosion (31), whereas the presence of collagenase in the medium enhances demineralization (32), implying a mutual effect on the organic and inorganic substance. With collagen degradation, especially in advanced erosions, the mineralized tissue portions are undermined, i.e. in the process of demineralization of the inorganic tooth component, the effect of collagenase extends to the organic portion, thus precipitating the process of tooth substance loss. With the additional effect of tooth friction by the masticatory musculature, tongue and lips, and the abrasive action of food and tooth brushing, it becomes evident that multiple causative mechanisms of erosive tooth wear are involved in tooth erosions (tribology).

Dynamic changes in our working and living environment, altered dietary habits, and ever greater knowledge about the biochemical mechanisms of erosion have stimulated us to focus, beside the classical picture of erosion, on the study of so-called subclinical erosions. An example of predisposing factors for these states are subclinical forms of gastrointestinal tract disorders (silent regurgitation) in endogenous erosions, an allowed amount of acidic vapors found in the working area in occupational erosions, and frequent intake of fruit juice, a common habit, in dietary erosions. These are states that make the external or internal environment potentially hazardous for highly mineralized tooth tissues, compromising the mechanisms of enamel remineralization, which is considered the natural mechanism of tooth protection, and leading to impairment of the oral system homeostasis (biologic stability). Beside the factors mentioned above, the occurrence and extent of this stability impairment depends on the amount and composition of the saliva, its buffering capacity, density of enamel mineralization (13), masticatory system pattern, and dietary and hygienic habits, the latter because the attrition-abrasion component is an inevitable factor in the removal of undermined microstructural segments of the mineralized tissue. Clinically, the condition may assume various manifestations. In individuals with high standards of oral hygiene, the compromised homeostasis will manifest as idiopathic erosions or just as tooth hypersensitivity to thermal, chemical or mechanical stimuli, whereas in those with low oral hygiene standards it will manifest as a caries increase compared to the rest of the population from the same setting (29). In the former, the functional activity of the masticatory system and tooth brushing, causing peeling off of superficial and subsuperficial microlesions, result in smooth, eroded enamel de-

fects and/or exposed, conditioned and hypersensitive dentin. In the latter, the mechanisms of stability between the enamel and cariogenic microflora are lacking. Thus compromised, the enamel facilitates the microflora penetration through the physical barrier of the tooth, which then leads to carious cavitation of the enamel. In addition, Bevenius et al. (33) postulate that defects in the form of cervical erosions could be exclusively caused by occlusal stress in irregular lateral movements of the jaws.

Erosions of dental fillings essentially are a combination of several types of substance wear, i.e. erosion, corrosion and attrition (tribochemical wear). Initially, erosive undermining of the substance particles by a liquid medium with a certain concentration of hydrogen ions (pH) occurs. This is followed by chemical degradation of the substance (corrosion), and removal of the eroded material by surface friction with or without the abrasive component (attrition/abrasion) (1). Clinically, this condition presents as a partial loss of the filling with prominent enamel edges.

Method of examination

The study of abrasion, attrition and erosion, i.e. tooth wear, is based on clinical, laboratory and electronic examinations. The earliest findings were descriptive, and they made a basis for subsequent clinical studies, which are still unavoidable in spite of certain subjectivity they involve. The most common indices currently used in clinical studies are Smith and Knight's indices (34), where the loss of tissue on all surfaces is descriptively designated and measured in millimeters, slightly modified by some authors to adjust them to specific issues they tackled in their studies (10,18). More recent findings are supplemented by questionnaires in order to reveal any other possible etiologic factors (e.g., aerosol, regurgitation, vomiting, headaches, bruxism, bad habits, diet, occupation, etc.) that may have influenced the process of tooth wear (20). It has been shown that defects of various etiologies may have identical or very similar forms.

The follow-up of functional tooth wear in the same individuals has to be exercised over a prolonged period of time, using dental impressions and photographs (18,20) on which changes in the facets formed are measured. Teaford used SEM and microphotography to follow up scratches on the facets of monkey teeth in a study of tooth wear related to food abrasives over a short period of several weeks (35). Generally, SEM has been quite frequently used in this type of investigation (2,5,13,27). Lambert employed the computed tridimensional technique to measure the lost portion of the teeth (3). Viasis used the same technique to compare the wear of occlusal surfaces before and after the trial, and a combination of computer graphics and SEM to visualize the quantitative changes (grade of enamel wear) (5). In a study of nocturnal bruxism, Akamatsu used electromyography (for masseter function) and a magnetic sensor to designate the position of the mandible during bruxism (36).

As *in vivo* tests of tooth brushing abrasion have not yet been successfully standardized, various models of laboratory testing have been used, most reliable of them being the method with radioactive markers (4). Absi et al. used SEM to study the relationship between dentin tubuli and tooth paste ingredients, and the erosive effect of fruit juice (27). Pindborg used microradiography to visualize superficial and subsuperficial microerosions, and categorized defects found in clinically visible industrial erosions into four grades, from opacified enamel (grade 0) through tooth loss down to the pulp (grade 3) (2). Boyd used the method of air polishing with water and sodium bicarbonate as an abrasive, controlled by a stereobinocular microscope and SEM to test physical resistance of the enamel and dentin, and quantitative variations in microhardness of the eroded mineralized tissue (13).

All these examples indicate that researchers are no longer satisfied with classical methods of measurement in the study of tooth wear, and that the defect etiology and tribologic mechanisms of dental tissue and material wear have become the focus of their interest. Physiologic tooth wear is now measured in micrometers, because mechanical tooth wear resulting from dietary habits has become slower, whereas knowledge about erosions is increasing daily. For this reason attempts are being, made to standardize the known methods and to improve methods of investigation by the introduction of new technologies in the field, expected to help in detecting new particularities on this issue of utmost importance for dental medicine.