

# Gnatodinamska istraživanja u uvjetima patološkoga trošenja tvrdih zubnih tkiva

Dragutin Komar<sup>1</sup>  
Jadranka Keros<sup>2</sup>  
Biserka Lazić<sup>1</sup>  
Zoran Azinović<sup>3</sup>  
Ksenija Jorgić-Srdjak<sup>4</sup>

<sup>1</sup>Zavod za fiksnu protetiku,  
Stomatološki fakultet  
Sveučilišta u Zagrebu

<sup>2</sup>Zavod za dentalnu antropolo-  
giju, Stomatološki fakultet  
Sveučilišta u Zagrebu

<sup>3</sup>Zavod za dentalnu patologiju,  
Stomatološki fakultet  
Sveučilišta u Zagrebu

<sup>4</sup>Zavod za parodontologiju,  
Stomatološki fakultet  
Sveučilišta u Zagrebu

## Sažetak

Svrha je rada bila utvrditi uzročnu vezu između veličine žvačnih sila i patološke abrazije. Gnatodinometrijska mjerenja obavljena su na 30 muškaraca s izraženom kliničkom slikom patološke abrazije u dobi od 30 do 75 godina, te na ispitanicima kontrolne skupine ( $n = 50$ ) koju su tvorili mladi muškarci u dobi od 18 do 22 godine. Srednja je vrijednost žvačnih sila u ispitanika s abrazijom u desnom segmentu čeljusti 391 N, a u kontrolnoj skupini 496 N ( $t = -3,41$ ,  $p = 0,001$ ). Srednja vrijednost žvačnih sila u prednjem segmentu čeljusti u ispitanika s patološkom abrazijom iznosila je 282 N, a u kontrolnoj skupini 336 N ( $t = -2,59$ ,  $p = 0,011$ ). Srednje vrijednosti žvačnih sila u ispitanika s patološkom abrazijom u lijevom je segmentu čeljusti bila 388 N, a u kontrolnoj skupini 462 N ( $t = -2,27$ ,  $p = 0,026$ ). U skupini ispitanika s abrazijom postojala je obrnuto proporcionalna statistički značajna korelacija između veličina žvačne sile i gubitka zuba na istoj strani. Žvačne sile u ispitanika s parafunkcijama veće su nego u ostalih ispitanika.

Dobiveni rezultati pridonose poznavanju značenja žvačnih sila u nastanku abrazije, što je od osobito važno u svim stomatološkim disciplinama.

Ključne riječi: žvačne sile, gnatodinamska istraživanja, abrazija

Acta Stomatol Croat  
1998; 577—581

IZVORNI ZNANSTVENI  
RAD

Primljeno: 2. studenoga 1998.

Adresa za dopisivanje:

Dragutin Komar  
Zavod za fiksnu protetiku  
Stomatološkog fakulteta  
Sveučilišta u Zagrebu  
Gundulićeva 5,  
10000 Zagreb

## Uvod

Kretnje donje čeljusti uvjetovane su morfolo-  
gijom žvačnog sustava, to jest oblikom čeljusnih zglobova i zglobnih sveza, oblikom i položajem zubi i njihovih potpornih struktura, te aktivnom snagom

žvačnih mišića (1-10). Žvačne sile koje pri tome nastaju mjerom su žvačne funkcije, a ujedno su i fizi-  
kalna kategorija uvjetovana dinamičkom ili statič-  
kom aktivnošću mišića, što izravno ovisi o morfo-  
loškim značajkama žvačnog sustava. Nasuprot to-  
me aktivnost uvjetovanu poticajem i usklađivanjem

mišićnoga rada u određenom vremenu nazivamo snagom (6,7). Poznavati veličine žvačnih sila bitno je u dijagnostičkim postupcima većine stomatoloških disciplina, a o tomu ovisi i izbor najdjelotvornijih terapijskih postupaka. Žvačne sile uzrokuju mehaničko trošenje tvrdih zubnih tkiva što se ovisno o uzročnim čimbenicima označava nazivcima abrazija, atricija, abfrakcija i demastikacija. Problem se u suvremenim raspravama nastoji rasvijetliti s različitim aspektima kako bi se posve odredilo njegovo značenje u stomatološkoj praksi.

Trošenje tvrdih zubnih tkiva samo se do određenoga stupnja smatra fiziološkom pojavom. Gubitak tvrdih zubnih tkiva kompenzira se reparacijskim i regeneracijskim procesima. No ti se prirodni obrambeni procesi mogu samo donekle suprotstaviti štetnim etiološkim čimbenicima, a sva daljnja oštećenja tvrdih zubnih tkiva nazivamo patološkim. Takva oštećenja zuba i njegova potporna sustava naposljetku štete i cijelome stomatognatom sustavu budući da mijenjanjem morfoloških obilježja umanjuju njegovu djelotvornost (8-10).

Pojave prekomjernoga trošenja tvrdih zubnih tkiva nameću niz važnih pitanja o njihovim uzrocima i o mehanizmu nastanka. Zato smo nastojali pridonijeti razjašnjenju te pojave i utvrditi moguće suodnose veličina žvačnih sila s obzirom na životnu dob, zanimanje, cjelovitost zubnoga niza u istraživanome segmentu čeljusti i parafunkcije.

### Ispitanici i postupci

U istraživanju utjecaja žvačnih sila na nastanak patološke abrazije proveli smo gnatodinometrijska istraživanja u ispitanika s izraženom kliničkom slikom patološke abrazije (Skupina 1) i u usporedbenoj skupini ispitanika bez abrazije (Skupina 2). Skupina ispitanika s abrazijom obuhvaćala je 30 muškaraca životne dobi od 30 do 75 godina, a kontrolnu skupinu ispitanika činilo je 50 muškaraca životne dobi od 18 do 22 godine s potpunim i uredno saniranim zubalima.

Vrijednosti žvačnih sila i status svakog ispitanika upisivali smo u za tu prigodu načinjen upitnik. U posebne smo rubrike upisivali podatke poput noćnoga škripanja i staskanja zuba pri fizičkom radu, uzbuđenosti i srdžbi, te druge značajke bitne za nastanak patološke abrazije.

Za mjerenja žvačnih sila rabe se gnatodinometri s mehaničkom osnovom koji pripadaju najjednostavnije koncipiranim spravama. Sila se mjeri temeljem deformacije zavojnice, opruge ili drugoga prikladnoga gradbenog dijela naprave. Posredstvom prijenosnog mehanizma veličina se deformacije koja nastaje djelovanjem sile iskazuje pomakom kazaljke na mjernoj ljestvici ili na mjernome satu. Danas postoje vrlo uspješne modifikacije tih naprava primjenom elektrootpornih mjernih traka (strain gauge).

U našim smo se mjerenjima služili posebno konstruiranim mehaničkim gnatodinometrom metalne osnove, oblika žlice, na krajevima kojeg su 6 mm debele željezne hvataljke obložene promjenljivim nastavcima izrađenim iz vakumirane gume 70%-tne čvrstoće u koje su ispitanci grizli. Na metalnu je osnovu pričvršćen manometar. Ugriz na hvataljke uvjetovao je odklon kazaljke na mjernome satu, što je omogućilo očitavati vrijednosti žvačnih sila (11-13).

Mjerenja su obavljena u frontalnom segmentu čeljusti i oba lateralna, i to po tri puta u svakome segmentu zubnoga luka. Od očitavanih vrijednosti izdvajali smo najveće i zatim ih statistički raščlanjivali.

### Rezultati

Razlike veličine žvačnih sila te razlike životne dobi u istraživanim skupinama, prikazane u Tablici 1., pokazale su se statistički značajnim.

U istraživanju je skupini ispitanika s abrazijom srednja vrijednost za životnu dob bila 34 godine, a u usporedbenoj 20 godina. Srednja je vrijednost žvačnih sila u ispitanika s abrazijom u desnom segmentu čeljusti 391 N, a u kontrolnoj skupini 496 N ( $t = -3,41$ ;  $p = 0,001$ ). Srednja je vrijednost žvačnih sila u prednjem segmentu čeljusti u ispitanika s abrazijom 282 N, a u kontrolnoj skupini 336 N ( $t = -2,59$ ;  $p = 0,011$ ). Srednja je vrijednost žvačnih sila u lijevom segmentu čeljusti u skupini ispitanika s abrazijom 388 N, a u kontrolnoj skupini 462 N ( $t = -2,27$ ;  $p = 0,026$ ).

U skupini ispitanika s abrazijom nije utvrđena statistički značajna korelacija između životne dobi i veličine žvačnih sila, a u kontrolnoj skupini takva korelacija nije provjerena zbog maloga dobnog raspona. Razlike u veličini žvačnih sila na lijevoj i na

Tablica 1. Razlika u dobi i veličini žvačne sile među skupinama

Table 1. Difference in age and intensity of masticatory force between study groups

Varijabla / Variable	Srednja / Mean vrijednost / value Skupina 1 / Group 1 N = 30	Srednja / Mean vrijednost / value Skupina 1 / Group 1 N = 50	SD Skupina / Group 1	SD Skupina / Group 2	t	p
Dob / Age	54	20	10	1	23,66	0,0000
Žvačna sila / Masticatory D. / force right	391	496	137	129	-3,41	0,001
Žvačna sila / Masticatory N. / force front	282	336	100	84	-2,59	0,011
Žvačna sila / Masticatory L. / force left	388	462	142	140	-2,27	0,026

desnoj strani u kontrolnoj skupini (*t*-test za zavisne uzorke) iskazane su u Tablici 2. Utvrđena je statistički značajno veća žvačna sila u desnom segmentu čeljusti nego u lijevom ( $t = 3,15$ ;  $p = 0,003$ ).

U skupini ispitanika s abrazijom postojala je statistički značajna korelacija (obrnuto proporcionalna) između veličina žvačnih sila i gubitka zuba na istoj strani. Pritom je odnos žvačne sile i gubitka zuba na desnoj strani  $t = -0,397$ ;  $p = 0,04$ . Odnos žvačne

sile i gubitka zuba na lijevoj strani bio je  $t = -0,379$ ;  $p = 0,04$ . Odnos žvačne sile i gubitka zubi u prednjem segmentu čeljusti bio je  $t = -0,49$ ;  $p = 0,006$ .

U Tablici 3 nastojali smo raščlambom varijance istražiti statistički značajnu razliku veličine žvačnih sila u skupini ispitanika s abrazijom u odnosu spram zanimanja i parafunkcije. Statistički značajnu razliku pokazala je samo na lijevoj strani u odnosu veličine žvačne sile i parafunkcija ( $F = 23,5$ ;  $p = 0,006$ ). Pritom su žvačne sile u ispitanika s parafunkcijama redovito bile veće nego u ostalih ispitanika.

Tablica 2. Odnos žvačnih sila lijevo i desno u kontrolnoj skupini.  $t = 3,15$ ;  $p = 0,003$ Table 2. Correlation between masticatory forces on the left and right sides in the control group.  $t = 3.15$ ;  $p = 0.003$ 

Varijabla Variable	Srednja vrijednost Mean value	SD
Žvačna sila desno Masticatory forces R.	495	130
Žvačna sila lijevo Masticatory forces L.	462	140

## Rasprava

Čimbenici koji utječu na iskazane vrijednosti žvačnih sila jesu položaj točke zagriža, histokemijski tip vlakana žvačnih mišića, okomita dimenzija okluzije (VDO) te stupanj otvorenosti usta (14,15).

U odraslih je ispitanika primjerice znatna razlika intenziteta žvačnih sila s normalnim licem i onih

Tablica 3. Razlika u veličini žvačnih sila u eksperimentalnoj skupini u odnosu prema zanimanju i posebnome nalazu

Table 3. Difference in intensity of masticatory force in the experimental group with regard to occupation and specific finding

Poseban nalaz Specific finding	Žvačna sila desno Masticatory force right	Žvačna sila naprijed Masticatory force anterior	Žvačna sila lijevo Masticatory force left
0	384	264	363
Bruksizam Bruxsizam	434	317	428
Stiskanje zubi Clenchin of teeth	412	316	481

s izduženim licem. Pri tome ljudi s normalnom visinom lica razvijaju dva do tri puta veće žvačne sile, što pripisujemo biomehaničkim razlicitostima žvačnog sustava (16-20). Zbog prekomjernoga trošenja zubnih tkiva pod utjecajem žvačnih sila mijenjaju se i međučeljsni odnosi i u vodoravnoj i u okomitoj relaciji (14,15,21-23).

Mjerenjima žvačnih sila bavili su se mnogi istraživači. Ringquist (24) primjerice, navodi da su prosječne vrijednosti žvačnih sila u lateralnim segmentima 477 N, što je gotovo istovjetno vrijednostima koje je izmjerila Kurliandsky (25).

Volker (26) navodi kako je prosječna vrijednost žvačnih sila u području premolara 480 N, a u području molara 520 N.

Naša su istraživanja pokazala nešto manje vrijednosti žvačnih sila, što je moguće objasniti činjenicom da navedeni autori ne navode nalaz patološke abrazije kakav je prikazan u našem uzorku. To je moglo biti razlogom djelovanja prilagodbenih mehanizama kojima je prvotna žvačna sila umanjena. Zato je i svrha našega rada bila utvrditi veličine žvačnih sila u abradiranom i neabradiranom zubalu. U ovih istraživanih skupina zabilježena je statistički značajna razlika.

Veličine žvačnih sila u istraživanim skupinama razlikuju se i prema životnoj dobi, no ta je razlika vjerojatno isključivo uvjetovana kriterijem odabira u skupine. Naime, raspon je godina u skupini ispitanika s abrazijom bio mnogo veći nego u kontrolnoj skupini.

Prosječne vrijednosti žvačnih sila u ispitanika s izraženom kliničkom slikom patološke abrazije manje su od onih u kontrolnoj skupini i to u cijelom uzorku za 18,12%. Pri tome te razlike za desno bočno područje iznose 21,08%, za prednje područje 16,14%, te za lijevo bočno područje 17,13%. U području su prednjih zuba zabilježene manje vrijednosti žvačnih sila nego u oba bočna područja i to za 30,32%, što je nalaz koji se slaže s istraživanjima Ivaniša i sur. (13).

U kontrolnoj skupini postojale su statistički značajno veće žvačne sile u desnom segmentu čeljusti u odnosu na prema lijevom ( $t = 3,15$ ;  $p = 0,003$ ). U ispitanika s patološkom abrazijom nema korelacije između životne dobi i žvačnih sila, što ne znači da nema takve povezanosti nego ona može biti poništena utjecajem gubitka zuba i parafunkcijama.

Poznato je, naime, da se u potpunom zubnom nizu sila koja djeluje na svaki zub posebice preraspoređuje doticajnim točkama i na preostale zube. U naših ispitanika s izraženom kliničkom slikom abrazije zbog nepotpunosti je zubnih nizova nastao gubitak kontaktnih točaka, što je moglo uzrokovati da se iskažu manje vrijednosti žvačnih sila u usporedbi s kontrolnom skupinom. Raspored i raspon nedostajućih zuba također su bitni u procjeni žvačnih sila, pa se primjerice pri razmjerno povoljnom rasporedu i postojanju većeg broja zuba dobivaju i veće vrijednosti izmjerenih žvačnih sila. O broju i rasporedu preostalih zuba ovisi i navika ispitanika da zbog osjećaja sigurnosti prigodom žvakanja više rabe jednu stranu zubala pa su na toj strani i žvačne sile veće. Postavku da češća funkcija utječe na povećanje žvačnih sila potkrepljuje i pojava parafunkcija pri kojima su redovito registrirane veće žvačne sile neovisno o životnoj dobi i broju postojećih zuba. Zato je u skupini ispitanika s abrazijom zabilježena znatna obrnuto proporcionalna korelacija između žvačne sile i gubitka zuba na istoj strani (desno  $t = -0,397$ ;  $p = 0,03$ ; sprijeda  $t = -0,379$ ;  $p = 0,04$ ; lijevo  $t = -0,49$ ;  $p = 0,006$ ).

U skupini ispitanika s abrazijom raščlambom varijance nije utvrđena statistički značajna razlika veličina žvačnih sila u vezi sa zanimanjem, što također može biti posljedicom nedostatnog uzorka tako da bez daljnjih istraživanja nije moguće procijeniti tu pojavu. Veličina žvačnih sila u ispitanika s abrazijom u odnosu prema parafunkciji u lijevom je segmentu čeljusti pokazala statističku značajnost ( $F = 23,5$ ;  $p = 0,006$ ), a žvačne su sile u ispitanika s parafunkcijama bile veće nego u drugih ispitanika.

## Zaključci

Temeljem naših istraživanja zaključujemo:

- da su razlike u veličini žvačnih sila među istraživanim skupinama znatne;
- da mlađi ispitanici (kontrolna skupina) s intaktnim ili saniranim zubnim nizom iskazuju mnogo veće žvačne sile od ispitanika s abrazijom (eksperimentalna skupina);
- da u eksperimentalnoj skupini nije utvrđen znatan međudobni odnos dobi i veličine žvačnih sila, što je moguće različito tumačiti;

- da nije opažena statistički značajna razlika u veličini žvačnih sila u eksperimentalnoj skupini u odnosu prema zanimanju i posebnome nalažu.

Dobivene rezultate smatramo preliminarnima, a istraživanja treba nastaviti pomnijim odabirom skupina što se tiče dobne, morfološke i funkcijske osobitosti zubala.

## Literatura

1. EIJDEN TMGJ., KOOLSTRA JH., BRUGMAN P.: A feedback method to determine the three dimensional bite force capabilities of the human masticatory system. *J Dent Res* 1988; 67 : 450-454.
2. ATKINSON HF., RALPH WJ.: Tooth losse and biting force in man. *J Dent Res* 1973; 52 : 225-232.
3. WALTIMO A., KÖNÖNEN M., RUSSEL MD: The distinction between physical and pathological attrition. *J Irish Dent Assoc* 1987; 33 : 23-31.
4. MANNS A., MIRALLES R., PALAZZI C: EMG bite force and elongation of the masseter muscle under isometric voluntary concentracion and variation of vertical dimensions. *J Prosthet Dent* 1979; 42 : 674-682.
5. SMITH BGN., KNIGHT JA.: A comparison of patterns of tooth wear with aethiological factors. *B Dent J* 1984; 157: 16-19.
6. MUFTIĆ O, LABAR J: Modelling of the head and cervical spine in biomechanical analysis. *Coll Antropol* 1990; 14 : 123-132.
7. KEROS-NAGLIĆ J, BAGI Č., MUFTIĆ O: Contribution for studying the functional structure and face skeletal strength. *Coll Antropol* 1991; 15 : 153-169.
8. BERRY DC, POOLE DF: Attrition: Possible mechanisms of compensation. *J Oral Rehabil* 1976; 3 : 201-206.
9. WALTIMO A, NYSTROM M., KÖNÖNEN M: Bite force and dentofacial morphology in men with severe dental attrition. *Scand J Dent Res* 1994; 102 : 92-98.
10. SASAKI K, HANNAM AG, WOOD WW: Relationships between the size position and angulation of human jaw muscle and unilateral first molar bite force. *J Dent Res* 1989; 68 : 499-503.
11. ŽIVKO J: Komparativna studija gnatodinometrijskih metoda s posebnim obzirom na vlastitu konstrukciju. Magistarski rad. Sveučilište u Zagrebu, 1980.
12. KOMAR D: Gnatodinometrijska ispitivanja u uvjetima patološke abrazije. Magistarski rad. Sveučilište u Zagrebu, 1985.
13. IVANIŠ T, ŽIVKO-BABIĆ J, KOMAR D, ČATOVIĆ A: Relationship between bite forces and main anthropometric dimensions. *Coll Antropol* 1996; 26 : 377-386.
14. XONGA FA: Bruxism and its effect on the teeth. *J Oral Rehabil* 1977; 4 : 65-76.
15. VALENTA J: Biomechanika. Academia Praha, 1985.
16. CHROTHERS A jr.: Vertical height differences in subjects with severe dental wear. *Eur J Orthod* 1993; 15 : 519-524.
17. WESTERGAARD J: Exaggerated abrasion / erosion of human dental enamel surfaces: a case report. *Scand J Dent Res* 1993 ; 10 : 265-272.
18. TEAFORD MF, TYLEND CA: A new approach to the study of tooth wear. *J Dent Res* 1991 ; 70 : 204-207.
19. TALGREN A, REINHARD GA: Attrition and the edge to edge bite. *Angle Orthod* 1983; 53 : 157-164.
20. SOLOW B: The dento-alveolar compensatory mechanisms. *Br J Orthod* 1980;7:145-161.
21. MAAS MC: A scanning electron-microscopic study of *in vitro* abrasion of mamalian tooth enamel under compressive loads. *Arch Oral Biol* 1994; 39: 1-11.
22. MUFTIĆ O: Harmonical anthropometry as the base for applied dynamic anthropometry. Faculty of Mechanical Engineering University of Zagreb, 1984.
23. PROMBONAS A, VLISSIDIS D, MOLYVDAS P: The effect of altering the vertical dimension of occlusion on biting force. *J Prosthet Dent* 1994;71:139-143.
24. RINGQUIST M: Isometric bite force and its relation to dimension of facial skeleton. *Acta Odontol Scand* 1973; 31: 35-42.
25. KURLYANDSKY V: Orthopedic stomatology. Mir Publishers, Moscow., 1977.
26. VOELKER N, SONNENBURG M: Belastbarkeitsmessungen der Zahne in verschiedenen Alterstufen. *DZZ* 1984: 39 - 54.

# Gnathodynamic Studies in Conditions of Pathological Abrasion of Hard Dental Tissues

Dragutin Komar<sup>1</sup>  
Jadranka Keros<sup>2</sup>  
Biserka Lazić<sup>1</sup>  
Zoran Azinović<sup>3</sup>  
Ksenija Jogić-Srdjak<sup>4</sup>

<sup>1</sup>Department of Fixed  
Prosthetics, School of Dental  
Medicine University of  
Zagreb

<sup>2</sup>Department of Dental  
Anthropology, School of  
Dental Medicine University of  
Zagreb

<sup>3</sup>Department of Dental  
Pathology, School of Dental  
Medicine University of  
Zagreb

<sup>4</sup>Department of Parodonto-  
logy, School of Dental  
Medicine University of  
Zagreb

---

## Summary

*The principal study objective was to define causative relation between masticatory forces and pathological abrasion. Gnathodynamometric measurements were made in 30 males aged from 30 to 75 years aged from 30 to 75 years with marked clinical signs of pathological abrasion, and in control subjects (n = 50) comprising young males aged from 18 to 22 years. The mean value of masticatory force intensity in subjects with abrasion in the right segment of the jaw was 391 N, while in the control group it was 496 N ( $t=-3.41$ ;  $p=0.001$ ). The mean value of intensity of masticatory forces in the anterior segment of the jaw in subjects with pathological abrasion was 282 N and 336 N in the control group ( $t=-2.27$ ;  $p=0.026$ ). The mean value of masticatory force intensity in subjects with pathological abrasion in the left segment of the jaw was 388 N and 462 N in the control group ( $t=-2.27$ ;  $p=0.026$ ). In the group of subjects with abrasion inversely proportionate statistically significant correlation was found between the intensity of masticatory force and loss of a tooth on the same side. Masticatory forces in subjects with parafunctions have shown to be greater than in other study subjects.*

*The obtained results contribute to knowledge on the significance of masticatory forces in the development of abrasion, which is of utmost importance in all fields of dentistry.*

**Key words:** mastication forces, gnathodynamic studies, abrasion

---

Acta Stomatol Croat  
1998; 583—586

ORIGINAL SCIENTIFIC  
PAPER  
Received: November 2, 1998

Address for correspondence:

Dragutin Komar  
Department of Fixed  
Prosthetics,  
School of Dental Medicine  
University of Zagreb  
Gundulićeva 5  
10000 Zagreb

## Introduction

Movements of the lower jaw are affected by morphology of the masticatory system, i.e. by the shape of gnathic joints and articular attachments, shape and position of teeth and their supporting structures, and by active strength of masticatory muscles (1-10). Masticatory forces occurring in this process are a measure of mastication function and at the same time they are a physical category influenced by dynamic or static muscle activity, directly depending on morphological properties of masticatory system. On the other hand, the activity resulting from stimulation and co-ordination of muscle activity in a given time is defined as strength (6,7). Knowing the strength, or intensity, of masticatory forces is essential to diagnostic procedures in most dental specialties, and the selection of most effective therapeutic techniques also depends on this knowledge. Masticatory forces cause mechanical wearing of hard dental tissues that, depending on causative agents, is referred to as abrasion, attrition, abfraction and demastication. Current discussions are aimed at clarifying the problem from different aspects in order to completely define its meaning in dental practice.

Only up to a certain degree is abrasion of hard dental tissues considered a physiological process. Loss of hard dental tissue is compensated for by reparative and regenerative processes. These natural defence mechanisms may, however, be only to a certain extent counterposed to harmful etiologic factors, whereas all further damages of hard dental tissues are defined as pathological. This damage to teeth and their supportive system eventually cause harm to the entire stomatognathic system, because by changing morphological characteristics they reduce its efficacy (8-10).

Excessive wearing of hard dental structures imposes a number of important questions about their causes and mechanisms of occurrence. Our aim was to contribute to the clarification of this phenomenon and to find out the inter-relationships between intensities of individual masticatory forces with regard to age, occupation and completeness of dental sequence in the analysed segment of the jaw and parafunctions.

## Material and methods

The study on how masticatory forces affect the development of pathological abrasion was carried

out by gnathodynamometric assessment of a sample of patients with visible clinical signs of pathological abrasion (Group 1) and a sample of study subjects showing no signs of abrasion (Group 2). The group of study subjects with signs of abrasion included 30 males aged from 30 to 75 years, while the control group comprised 50 males aged from 18 to 22 years with complete and well-cured dentition.

The values obtained for the intensity of masticatory forces and dental status of each study subject were recorded in a special form. There were also special columns for recording of information such as: nocturnal bruxism and clenching of teeth during physical labour, excitement and anger, together with other characteristics important to the development of pathological abrasion.

Gnathodynamometers with mechanical base, also considered as the most simply devised instruments, are commonly used in the measurement of masticatory forces. The force is measured on the basis of deformity of a spring or some other appropriate structural segment of the device. Through the transmission mechanism the extent of deformity resulting from action of force is recorded by deflection of a needle on the scale or the clock. Today modern modifications of these instruments exist that apply a strain gauge.

For the purpose of our measurements a specially devised mechanical gnathodynamometer was used with a metal spoon-shaped base at the ends of which there were 6 mm thick iron clamps coated with changeable pieces made of 70%-resistant vacuum rubber, which the study subjects had to bite. Manometer was attached to the metal base. A bite on clamps caused deflection of a gauge needle making it possible to read out the values of masticatory forces, similar to the procedure employed in previous studies (11-13).

Measurements were made in frontal and both lateral jaw segments three times at each segment of a dental arch. The highest values were selected and statistically analysed.

## Results

The differences between masticatory forces and differences in age presented in Table 2 have proved statistically significant.

The mean age in the group of experimental study subjects was 34 years and in the control group 20 years. The mean value of masticatory forces in subjects with abrasion in the right segment of the jaw was 391 N and 496 N in the controls ( $t=-3.41$ ;  $p=0.001$ ). The mean value of masticatory forces in the anterior segment of the jaw in subjects with abrasion was 282 N and 336 N in the control group ( $t=-2.59$ ;  $p=0.011$ ). The mean value of masticatory forces in the left segment of the jaw in subjects with abrasion was 388 N and 462 N in the controls ( $t=-2.27$ ;  $p=0.026$ ).

In the group of subjects with abrasion no statistically significant correlation was found between age of the subject and value of masticatory forces, while in the control group the correlation was not evaluated because of the very small age range. Differences in values of masticatory forces between the left and the right sides in the control group (*t-test* for dependent samples) are shown in Table 2. Statistically significantly greater masticatory force was found in the right jaw when compared with the left segment of the jaw ( $t=3.15$ ;  $p=0.003$ ).

In the group of subjects with abrasion statistically significant correlation was found (inversely proportionate) between values of masticatory forces and loss of a tooth on the same side. The relation between masticatory force and tooth loss on the right side was  $t = -0.379$ ;  $p=0.04$ . The relation between masticatory force and loss of a tooth on the left side was  $t = -0.379$ ;  $p=0.04$ . The relation between masticatory force and tooth loss in the anterior segment of the jaw was  $t = -0.49$ ;  $p=0.006$ .

Analysis of variance was used to study statistically significant difference between masticatory forces in the group of subjects with abrasion in relation to occupation and parafunctions (Table 3). Statistically significant difference was found between the value of masticatory force and parafunction only on the left side ( $F=23.5$ ;  $p=0.0006$ ). Masticatory forces in subjects with parafunctions were always greater than in other study subjects.

## Discussion

Among the factors influencing the obtained values of masticatory forces are the position of biting point, histochemical type of masticatory muscle fi-

bres, vertical occlusal dimension (VOD), and degree of openness of the mouth (14,15).

In adult subjects, for instance, significant difference in the intensity of masticatory forces has been noticed between subjects with normal and those with elongated faces. People with normal facial height develop two to three times greater masticatory forces, which is ascribed to biomechanical variations in the masticatory system (16-20). As a result of excessive wearing of dental tissues under the influence of masticatory forces, the inter-gnathic relationships undergo changes both in horizontal and vertical relations (14,15,21-23).

Many scientists have carried out measurements of masticatory forces. Ringquist (24), for instance, reports the average values of masticatory forces in lateral segments to be 477 N, which is almost identical to the values reported by Kurliandsky (25).

Volker (6) states the average value of masticatory forces in the premolar region to be 480 N and 520 N in the molar region.

Our research results show somewhat lower values of masticatory forces, which may be accounted for by the fact that the above mentioned authors do not report on the finding of pathological abrasion as presented in our sample that might be the reason for the action of adjustment mechanisms which reduce the initial masticatory force. Therefore, the primary objective of our study was to determine the intensity of masticatory forces in abraded and non-abraded dentition. Statistically significant difference was found between the two groups of study subjects.

The intensity of masticatory forces differs between the study subjects with regard to their age, although the difference is probably first of all due to criteria in selection of the sample. Namely, the age range in the group of subjects with abrasion was much greater than that in the control group.

The average values of masticatory forces in subjects with marked clinical signs of pathological abrasion were 18.12% smaller for than in the control group, in the entire study sample. The difference referring to the right lateral region is 21.08%, for the anterior region 16.14%, and for the left lateral region 17.13%. In the region of the anterior teeth the values of masticatory forces were 30.32% smaller when compared with those in both lateral regions;



the finding is in accordance with a study carried out by Ivaniš et. al. (13).

In the control group statistically significantly greater masticatory forces were noticed in the right segment of the jaw when compared with the left segment ( $t=3.15$ ;  $p=0.003$ ). In study subjects with pathological abrasion no correlation was found between their age and masticatory forces, which, however, does not mean that no such correlation exists, but rather that it can be annihilated by the influence of tooth loss and parafunctions. Namely, it is an established fact that in a complete dental sequence the force acting upon each tooth is redistributed across the contact points over other teeth. In our subjects with markedly visible clinical signs of abrasion due to incomplete sequences of teeth the contact points have been lost and this could have caused smaller values in masticatory forces when compared with the control group. The arrangement and range of missing teeth are also important in the assessment of masticatory forces so that, for instance, in a relatively good sequence and presence of a larger number of teeth greater values of the measured masticatory forces are obtained. As the habit of using one side of dentition for reasons of safety during mastication depends on the number and arrangement of the remaining teeth, the consequence is that the masticatory forces on this side are of greater intensity. The assumption that frequent use affects an increase in masticatory force is substantiated by parafunctional phenomena which always result in greater masticatory forces regardless of age and number of teeth. Therefore, in subjects with abrasion an inversely proportionate correlation was noticed between masticatory force and loss of a tooth on the same side (right  $t=-0.397$ ;  $p=0.03$ ; anteriorly  $t=-0.379$ ;  $p=0.04$ ; left  $t=-0.49$ ;  $p=0.006$ ).

In the group of subjects with abrasion analysis of variance did not show statistically significant difference in the intensity of masticatory forces with regard to occupation, which may also be accounted for by the small number of study subjects, so that further research is needed in order to properly evaluate the observed phenomenon. The intensity of masticatory forces in subjects with abrasion in relation to parafunctions in the left segment of the jaw showed statistical significance ( $F=23.5$ ;  $p=0.006$ ), whereas masticatory forces in subjects with parafunctions were greater than in other study subjects.

### Conclusions

Based on our study results the following may be concluded:

- differences in the intensity of masticatory forces between the groups of study subjects were statistically significant;
- younger subjects (control group) with intact or cured dental sequence exhibited masticatory forces of greater intensity than the subjects with abrasion (experimental group);
- in the experimental group no significant correlation was found between the age and intensity of masticatory forces, which may be explained in a number of different ways;
- no statistically significant difference was found in the intensity of masticatory forces in the experimental group with regard to occupation and specific findings.

The obtained results are considered preliminary and research should be continued with a more appropriate selection of study sample, especially in view of age and morphological and functional characteristics of dentition.