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Aging Quantification on Alveolar Bone Loss

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A B S T R A C T

Objectives were to measure labial alveolar resorption using Lamendin's method; to correlate the measured values of resorption with age at death; to determine whether age influences alveolar resorption, and if so, to quantify this impact. The study was performed during the 1992–1995 period in identified war casualties in Bosnia and Herzegovina. Data on the date, month and year of birth, and on the month and year of death were known in all cases. Measurements were carried out in 845 anterior monoradicular maxillary and mandibular teeth from male bodies (n=198) aged 23–69, divided into five age groups of 23–29, 30–39, 40–49, 50–59 and 60–69 years. Teeth with macroscopic pathologic lesions were excluded from analysis. Lamendin's method was used to measure the alveolar bone level on the labial aspect of the extracted teeth. Results are presented in tables. Regression analysis was used to determine the alveolar resorption increase with age. Results are also presented by the factor of alveolar resorption, where the youngest age group was divided by older age groups. In the total sample of 845 teeth, alveolar bone level of up to 3.49 mm was recorded in 740 (87.76%), of 3.50–5.99 mm in 99 (11.79%), and of >6.00 mm in 6 (0.71%) teeth. In anterior monoradicular teeth, labial alveolar resorption increased with age and showed a regular age dependent pattern toward older age groups in mandibular but not in maxillary teeth. A >6-mm pocket was very rarely recorded. Study results contribute to clinical practice, demonstrating that periodontology is a preventive discipline in dental medicine.

Key words: *periodontal disease, alveolar bone loss, alveolar resorption, aging*

Introduction

Teeth with the jaws are the most stable and most resistant parts of the human body postmortem, therefore being used for research in the fields of anthropology, archeology, anatomy, pathology, and forensic medicine[1]. Dental caries, periodontal disease and occlusion anomalies with associated complications account for about 90% of dental medicine practice, and their genesis can easily be followed in skeletal findings in archeology and pathology[2]. Dental and alveolar physiological and pathophysiological changes are used in postmortem assessment of age at death[3]. The growth and development of teeth is a continuous process that begins in fetal period to continue in the neonatal, juvenile and adult period, and appears to be under a more strict genetic control than the development of most skeletal elements. In a population of a particular chronological age, dental age is known to exhibit less variation than the age estimated on the basis of skeletal parameters[4]. It has been confirmed by changes observed in exhumed remains of war casualties in Bosnia and Herzegovina (1992–1995), with pronounced damage to sternal aspects of the ribs, vertebrae and pubic bone symphysis. In mass graves, especially in pits, or in forensic cases, skull may be separated from the corpse, thus dental methods are the methods of choice to determine the age at death[5]. The methods of age estimate based on the closure of cranial sutures are less commonly used in practice because of a rather low level of precision[6]. Gustafson was the first to systematically investigate and to develop statistical approach in the assessment of age at death in adult corpse according to dental and alveolar

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changes[7]. He specified the following six dental and alveolar changes associated with the process of aging: attrition, alveolar condition, secondary dentin, cement thickness, transparency or root sclerozation, and dental root resorption. He tested the accuracy of each of these six characteristics individually and in combinations, and developed an arbitrary score system (score 0, 1, 2 and 3) according to the particular change expression. A score increase referred to the increase in age. Lamendin et al. used dental factor (dental root transparency) and alveolar factor (alveolar resorption) on age assessment (Lamendin's or Paris sample)[8]. Alveolar resorption reflects on the tooth root. The affected site of the root is seen as a yellowish and smooth area apically from the enamel, darker than the enamel but brighter than the rest of the root. Alveolar resorption was measured on the labial aspect of the tooth and expressed as maximal distance between the cementoenamel junction and the line of epithelial attachment. Dental root transparency is a physiological phenomenon that does not occur before age 20. It results from deposition of the crystal hydroxyapatite in dentin tubules, and is more pronounced when the tooth is put into a negatoscope (16 W). Transparency is measured on the labial surface of the tooth root, where it is most pronounced, whereas alveolar resorption is measured on the labial aspect, where it is less liable to the effect of pathologic processes of infection, inflammation and destruction[8]. Prince and Ubelaker have developed a new formula for dental age assessment, based on Lamendin's principle and additionally including the length of dental root calculated by multiple regression analysis (Terry – Washington sample)[9].

Alveolar resorption as a process of physiological involution, alveolar resorption as a pathophysiological process of infection, inflammation and destruction, and occlusal traumatization of damaged periodontium are difficult to distinguish due to the individuality and diversity of both systemic factors and oral eco system[10–16].

The aims of the study were as follows: a. to measure labial alveolar resorption according to the method of Lamendin; b. to correlate the measured values of alveolar resorption with the age at death; c. to determine whether age influences alveolar resorption; and d. if so, to quantify this effect.

Material and Methods

Material

The study included 845 monoradicular teeth from 198 male bodies aged 23–69 years at death. Two bodies aged 79 and 85 with one tooth each (13 and 33) were excluded from statistical evaluation. The study sample was collected from remains of war victims in Bosnia and Herzegovina (1992–1995) that were exhumed and properly identified (Sarajlić, Sarajevo sample). This method is not suitable for assessment of bodies below age 23[8,9]. In the study sample, the exact date, month and year of birth, and at least month and year of death were known in all cases. Anterior monoradicular teeth (maxillary and mandibular central and lateral incisor and canine teeth) were included in the study. Teeth with macroscopically visible pathologic lesions that may have influenced age assessment and teeth that sustained fracture on postmortem extraction were excluded from analysis. Male cases were chosen because male subjects accounted for more than 85% of war casualties in Bosnia and Herzegovina[5].

Method

Upon postmortem extraction performed by dental forceps for maxillary and mandibular tooth extraction, the teeth were cleaned and washed with water. Measurements were done by use of a digital vernier gauge on the labial aspect of monoradicular teeth, since Lamendin and Prince also performed measurements on the labial aspect of teeth in their studies[8,9]. The measured values were expressed in millimeters, to the hundredth of millimeter. Alveolar resorption was measured at the middle of the labial aspect of tooth, from the cementoenamel junction apically to the visible discoloration denoting the border of alveolar resorption.

All tooth measurements were categorized according to tooth groups and number of bodies *per* group (Table 1), and age groups (Table 2).

TABLE 1
SAMPLE DISTRIBUTION ACCORDING TO GROUPS OF TEETH

Teeth	11–21	12–22	13–23	31–41	32–42	33–43	Total
n (teeth)	122	105	128	143	165	182	845
n (bodies)	91	76	96	102	122	138	198

TABLE 2
SAMPLE DISTRIBUTION ACCORDING TO AGE GROUPS

Age (yrs)	23–29	30–39	40–49	50–59	60–69	Total
n (teeth)	145	269	206	147	78	845
n (bodies)	32	64	47	36	19	198

Statistics

On statistical analysis, mean ($\overline{X}$), standard error (SE), minimal (Min) and maximal (Max) values were calculated; t-test (p) was used to test differences in the means ($\overline{X}$) between older age groups and youngest age group for the same teeth. Regression analysis was employed to determine the possible increasing pattern of labial alveolar resorption with aging. The factor of alveolar resorption was calculated according to tooth age groups. The overall tooth sample was categorized into six age groups. Descriptive analysis according to age for each age group and tooth sample as a whole is presented in Table 3. The mean age for both tooth sample as a whole and for particular tooth groups was quite uniform, ranging from 41.02 to 42.26; the youngest and oldest individuals were aged 22.77 and 68.83 years, respectively.

TABLE 3
DESCRIPTIVE STATISTICS ACCORDING TO AGE FOR GROUPS OF TEETH AND SAMPLE AS A WHOLE

Age (yrs)/tooth	11–21	12–22	13–23	31–41	32–42	33–43	Total
$\overline{X}$	41.30	42.11	42.26	41.02	41.85	42.00	42.09
SE	1.21	1.34	1.28	1.13	1.07	1.08	0.89
SD	11.57	11.67	12.59	11.37	11.85	12.75	12.53
Min	23.50	23.64	23.64	23.00	22.77	22.77	22.77
Max	67.00	66.00	68.08	65.83	68.83	68.83	68.83

$\overline{X}$=mean (yrs); SE=standard error; SD=standard deviation; Min=minimal value; Max=maximal value

Results

Results of the measurement of labial alveolar resorption according to groups of teeth (11, 21, 12, 22, 13, 23, 31, 41, 32, 42, 33 and 43) are shown in Tables 4 and 5. Differences in the values of labial alveolar resorption between the youngest age group (23–29 years) and all other age groups were tested by Student's t-test.

Regression analysis was performed to determine the possible growing pattern of labial alveolar resorption with aging. Regression was calculated for each individual tooth with age group as independent variable and labial alveolar resorption value as dependent variable. Results showed an increasing tendency in labial alveolar resorption with aging for mandibular teeth ($R=0.866–0.99$; $p<0.05$) but not for maxillary teeth ($p>0.05$).

The factor of alveolar resorption was calculated by dividing the value of each age group by the value recorded in the youngest age group (23–29 years), arbitrarily set at 1.00 (Table 6, Figures 1 and 2). The value of alveolar resorption recorded in the youngest age group was taken as a baseline value. Aging is a process of physiological involution, therefore the values of alveolar resorption in older age groups were divided with the respective values recorded in the youngest age group.

The factor of alveolar resorption showed a regular pattern of quantitative increase toward older age groups in mandibular teeth but not in maxillary teeth. In comparison with the youngest age group (23–29 years), the factor of alveolar resorption was increased by 47%, 71%, 110% and 135% in the 30–39, 40–49, 50–59 and 60–69 age groups, respectively.

TABLE 4
LABIAL ALVEOLAR RESORPTION IN ANTERIOR MAXILLARY TEETH

Tooth	11			21			12			22			13			23		
Age	N	$\overline{X}$±SE	p	N	$\overline{X}$±SE	p	N	$\overline{X}$±SE	p	N	$\overline{X}$±SE	p	N	$\overline{X}$±SE	p	N	$\overline{X}$±SE	p
23–29	12	1.06±0.35		10	1.18±0.37		9	1.27±0.44		9	1.47±0.48		11	2.01±0.38		11	1.08±0.24	
30–39	15	1.40±0.20	NS	19	1.66±0.22	NS	12	1.63±0.26	NS	20	1.78±0.21	NS	23	1.66±0.22	NS	22	2.33±0.35	<0.05
40–49	18	1.45±0.24	NS	18	1.66±0.35	NS	10	1.49±0.39	NS	16	1.42±0.33	NS	14	1.93±0.27	NS	10	2.05±0.36	<0.05
50–59	10	2.09±0.30	<0.05	8	1.79±0.48	NS	10	2.04±0.51	NS	9	1.46±0.40	NS	10	2.08±0.51	NS	13	2.91±0.27	<0.05
60–69	5	1.79±0.29	NS	7	3.63±0.71	<0.001	5	2.29±0.79	NS	5	1.63±0.77	NS	6	2.61±0.53	NS	8	2.86±0.61	<0.05
χ^2	60	1.45±0.12	NS	62	1.69±0.15	NS	46	1.69±0.20	NS	59	1.57±0.16	NS	64	2.25±0.16	NS	64	2.25±0.61	<0.05

11=central incisor maxillary right; 21=central incisor maxillary left; 12=lateral incisor maxillary right; 22=lateral incisor maxillary left; 13=canine tooth maxillary right; 23=canine tooth maxillary left; n=number of teeth; χ=mean (mm); SE=standard error; p=level of significance

TABLE 5
LABIAL ALVEOLAR RESORPTION IN ANTERIOR MANDIBULAR TEETH

Tooth	31			41			32			42			33			43		
Age	N	$\overline{X}$±SE	p	N	$\overline{X}$±SE	p	N	$\overline{X}$±SE	p	N	$\overline{X}$±SE	p	N	$\overline{X}$±SE	p	N	$\overline{X}$±SE	p
23–29	11	0.90±0.29		16	0.90±0.18		14	1.20±0.33		13	1.20±0.40		17	1.50±0.35		12	0.90±0.25	
30–39	19	1.80±0.32	<0.05	29	1.80±0.22	<0.001	26	1.60±0.24	NS	23	2.10±0.20	NS	26	1.20±0.12	NS	35	1.40±0.14	NS
40–49	17	2.40±0.32	<0.001	18	2.10±0.34	<0.05	25	2.10±0.24	<0.05	19	2.50±0.20	<0.05	23	2.20±0.23	NS	18	2.30±0.34	<0.001
50–59	13	2.90±0.56	<0.001	11	2.90±0.45	<0.001	18	2.60±0.28	<0.001	12	2.60±0.40	<0.05	15	3.10±0.40	<0.001	18	2.20±0.31	<0.001
60–69	4	2.50±0.82	NS	5	3.50±0.77	<0.05	7	2.90±0.31	<0.001	8	3.20±0.30	<0.05	8	2.90±0.74	<0.05	10	2.70±0.36	<0.001
χ^2	64	2.10±0.19	<0.001	79	1.90±0.16	<0.001	90	1.90±0.15	<0.05	75	2.20±0.10	<0.05	89	2.00±0.15	<0.05	93	1.80±0.13	<0.001

31=central incisor mandibular left; 41=central incisor mandibular right; 32=lateral incisor mandibular left; 42=lateral incisor mandibular right; 33=canine tooth mandibular left; 43=canine tooth mandibular right; n=number of teeth; χ=mean (mm); SE=standard error; p=level of significance

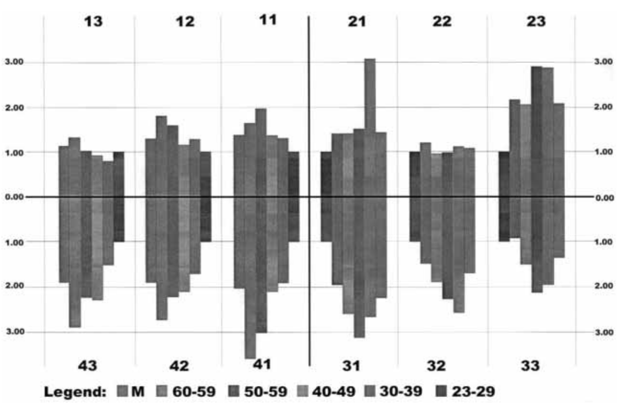

Fig. 1. Factor of labial alveolar resorption (FAR) in particular age groups according to aging dynamics.

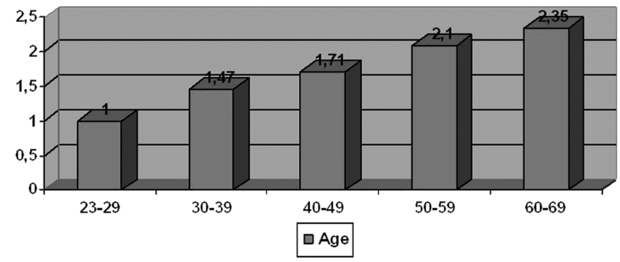

Fig. 2. Factor of labial alveolar resorption (FAR) in total sample according to aging dynamics.

The Community Periodontal Index of Treatment Needs (CPITN) is an epidemiological and clinical index used to quantify periodontal tissue destruction and required treatment in periodontal casuistics[17]. CPITN in correlation with aging is presented in Table 7.

Discussion

The loss of alveolar bone by resorption is the critical event in the pathogenesis of periodontal disease. Bone resorption is a complex process that is morphologically manifested by erosion of the bone surface (Howship's lacunes) and large multinuclear cells, osteoclasts. Another mechanism of bone resorption is the formation of acidosis environment, leading to dissolution of the bone constituent minerals. The mediators of bone resorption include prostaglandins, osteoclast activating factor (OAF), lipopolysaccharides (LPS), complement system, interleukins (IL-1, IL-3, IL-6), parathormone (PTH), macrophage colony stimulating factor (M-CSF), tumor necrosis factor alpha (TNF-α), tumor necrosis factor beta (TNF-β), and vitamin D3[18].

Severson et al.[19] demonstrated on human autopsy material that the cell count in the osteogenic part of the periodontium decreased with age. In the presence of inflammation, periodontitis develops at a faster rate in the elderly, whereas periodontal lesions heal at a slower rate. Destruction due to periodontal disease is ever more pronounced with aging[11]. Yet, the effect of aging on the

TABLE 6
CORRELATION BETWEEN FACTOR OF LABIAL ALVEOLAR RESORPTION AND AGING

Age (yrs)/tooth	11	21	12	22	13	23	31	41	32	42	33	43
23–29	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
30–39	1.32	1.41	1.28	1.21	0.83	2.16	1.95	1.89	1.48	1.73	0.83	1.52
40–49	1.37	1.41	1.17	0.97	0.96	2.05	2.59	2.10	1.82	2.16	1.52	2.38
50–59	1.97	1.52	1.61	0.99	1.02	2.91	3.12	3.02	2.28	2.28	2.13	2.30
60–69	1.65	3.08	1.80	1.11	1.30	2.86	2.67	3.58	2.57	2.78	1.95	2.86
$\overline{X}$	1.37	1.43	1.33	1.07	1.12	2.08	2.25	2.02	1.63	1.91	1.36	1.91
N (845)	60	62	46	59	64	64	64	79	90	75	89	93

TABLE 7
CORRELATION BETWEEN AGING AND CPITN

Age (yrs)	23–29	30–39	40–49	50–59	60–69	Total
n (teeth)	145	269	206	147	78	845
0.00–3.49 mm	138	251	180	115	56	740
%	95.17	93.30	87.38	78.23	71.80	87.57
3.50–5.99 mm	7	17	26	29	20	99
%	4.83	6.31	12.62	19.73	25.64	11.72
>6.00 mm	0	1	0	3	2	6
%	0.00	0.39	0.00	2.04	2.56	0.71

periodontal disease progression is negligible provided appropriate oral hygiene[12]. Epidemiological studies of periodontal health in Iowa have revealed 2.1% of individuals aged ≥55 to have >6 mm pockets[20]. In a healthy adult, the age alone does not lead to a critical loss of periodontal support. Although moderate loss of alveolar bone is common in the elderly, severe periodontitis is not a natural consequence of aging[21].

The cortical and trabecular bone of the 10 fresh cadavers mandibles from women is more sensitive to systemic influences where as that 11 cadavers mandibles from man is more sensitive to local influences. This is some what in agreement with some studies that found an association between osteoporosis and an alveolar bone loos[22,23]. A computer/digitizer recording method was utilized for the assessments of the relation alveolar bone height/root lenght (B/R) of 732 randomy selected adult individuals. The results showed reduction in man B/R with age. The women hat significantly more mean B/R ration than man in the ages above 40 years[24].

In their clinical study, Papapanou et al. investigated the relationship of the probing attachment level (PAL), probing pocket depth (PPD) and alveolar bone level (ABL) in 511 patients divided into five age groups (20–24, 30–34, 40–44, 50–54 and 60–64 years) and 50 control subjects free from manifest periodontal disease as the »best« cohort[13]. In the present study, PAL could not be assessed (postmortem study in war casualties), therefore we estimated ABL according to the method of Lamendin[8,25]. In the study by Papapanou et al., ABL of up to 3 mm was recorded in 100% of the »best« cohort, i.e. 20–24 age group, 98% of 30–34, 96% of 40–44, 95% of 50–54, and 88% of 60–64 age group, with only 3% of subjects with ABL >6 mm in the latter[13].

In the present study, according to CPITN criteria, there were 95.17%, 4.83% and 0.0% of cases with 3.49, 3.50–5.99 and >6 mm in 23–30 age group; 93.30%, 6.31% and 0.39% in 30–39 age group; 87.38%, 12.62% and 0.0% in 40–49 age group; 78.23%, 19.73% and 2.04% in 50–59 age group; and 71.80%, 25.64% and 2.56% in the oldest, 60–69 age group (Table 7).

Papapanou et al. report on ABL >6 mm recorded in 3% of only one age group (60–64 years), whereas we found it in 2.56% of teeth. In the Iowa study, it was recorded in 2.1% of the study population aged >55[20]. These data are relevant for clinical practice because overt periodontium destruction (>6 mm) is relatively rare. This is consistent with the report by Vrbič et al., who found CPITN in individuals aged >65 from a sample of 541 subjects to be 6.6%[26]. These findings were confirmed in a Bosnia and Herzegovina sample of 2580 subjects, where CPITN was 7%[27]. Accordingly, the majority of periodontal casuistics could be managed by preventive measures applied by the patient and properly treated by general dental practitioner. The methods of complex treatment of diseased periodontium according to TN=3 (>6 mm) criteria should be rarely needed. According to its large-scale utilization, periodontology should be an integral segment of primary health care, with general dental practitioner playing the key role[28].

Conclusions

The measurements of alveolar bone level according to Lamendin indicated the process of alveolar resorption on the labial aspect of anterior monoradicular teeth to increase with aging.

Regression analysis showed labial alveolar resorption to increase toward older age groups. Labial alveolar resorption expressed as factor of alveolar resorption on the anterior monoradicular mandibular teeth increased in older age groups, showing a regular time dependent pattern; the respective maxillary teeth also showed an increase in labial alveolar resorption toward older age groups, however, with a greater variability than the former.

When evaluated according to CPITN, the results obtained on alveolar bone level were comparable with those reported by Papapanou et al.[13]. In their study, there were 3% of teeth with alveolar bone level >6 mm in the 60–64 age group, whereas in the present study there were 2.56% of teeth with alveolar bone level >6 mm in the 60–69 age group, suggesting that an advanced stage of periodontal destruction (CPITN >6 mm) is relatively rare.

The present study may contribute to clinical practice with periodontology as a preventive discipline of dental medicine, and the majority of periodontal casuistics should be managed by general dental practitioners, and only a minor part referred to periodontologist.

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KVANTIFIKACIJA GUBITKA ALVEOLNE KOSTI U PROCESU STARENJA

S A Ž E T A K

Cilj ovog istraživanja bilo je mjerenje resorpcije labijalnog dijela alveole po metodi Lemendina, korelirati izmjerene vrijednosti resorpcije sa zaživotnom starosti, utvrditi da li dob utječe na resorpciju alveole, ako utječe kvantificirati u kojem iznosu. Istraživanje je izvršeno na identificiranim osobama, žrtvama rata u Bosni i Hercegovini u periodu 1992.–1995. godine. Kod svake žrtve bio je poznat dan, mjesec i godina rođenja kao mjesec i godina smrti. Mjerenja su izvršena na 845 frontalnih jednokorijenskih zubi maksile i mandibule (11–21; 12–22; 13–23; 31–41; 32–42; 33–43) koji su pripadali muškim osobama (198) starim između 23 i 69 godina podijeljenih u pet starosnih skupina (23–29; 30–39; 40–49; 50–59 i 60–69 godina). Eliminirani su zubi s makrosopskim patološkim promjenama. Na ekstrahiranim zubima na labijalnoj strani mjeren je »alveolar bone level« (ABL) po metodi Lamendina. Mjerenja su obavljena pomičnim mjerilom (digitalnim šublerom) i izraženi u milimetrima do stotog dijela milimetra. Rezultati su dati tabelarno: srednje vrijednosti ($\overline{X}$), standardna greška (SE), krajnji rasponi, a dobivene vrijednosti su testirane t-testom. Provedena je i regresijska analiza kako bi se utvrdilo postoji li tendencija povećanja labijalne alveolarne resorpcije prema starijoj dobi. Rezultati su pokazani i preko faktora alveolarne resorpcije (FAR), gdje je najmlađa dobna skupina dijeljena sa starijim dobnim skupinama. Razina alveolarne kosti »alveolar bone level« (ABL) u cjelokupnom uzorku od 845 zubi do 3,49 mm bio je kod 87,76% ili 740 zubi; od 3,50 do 5,99 mm bio je u 11,79% ili 99 zubi, a >6,00 mm bio je kod 0,71% ili 6 zubi. Resorpcija labijalne alveole frontalnih jednokorijenskih zubi sa starošću se povećava. Resorpcija labijalne alveole mandibularnih zubi prema starijim dobnim skupinama pokazuje vremensku zakonitost dok kod maksilarnih zubi te pravilnosti nema. Resorpcija >6 mm je vrlo rijetka. To je doprinos kliničkoj praksi da je parodontologija preventivna disciplina stomatologije i najveći dio parodontološke kazuistike pripada GDP a samo manji dio specijalisti parodontologu.