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ORIGINAL ARTICLE

The effect of frequent removable partial denture wearing on alveolar bone resorption

Daniela Kovačević Pavičić[1], Vlatka Lajnert[1], Sunčana Simonić Kocijan[1], Ivone Uhač[1], Snježana Glavičić[2], Zoran Kovač[1]

[1]Department of Prosthodontics , [2]Department of Endodontics and Restorative Dentistry; School of Medicine, University of Rijeka, Rijeka, Croatia

ABSTRACT

Aim To determine the influence of frequent removable partial denture (RPD) wearing on the alveolar bone density changes around the abutment teeth.

Methods Fifty examinees of both genders, wearing partial dentures, were included in the study. Thirty one of the examinees (62%) were wearing the dentures 24 hours a day, while nineteen (34%) of them were wearing them only during the day. The changes in the bone density around the abutment teeth were determined by the intraoral microdensitometry method. Standard retroalveolar radiographs were performed twice. The first one before the removable partial denture delivery and the second one after a period of three-month denture wearing. A copper step wedge consisting of five steps (0.1-0.5 mm) was attached to the radiograph in order to calibrate it. Seven points, regions of interest (ROI) close to the root of the abutment tooth, all ten pixels in size, were selected on each radiograph. Grey areas in the regions of interest were measured and converted into the copper step wedge thickness equivalents in order to estimate the change in the alveolar bone density and measure the difference in alveolar bone density between two radiographs.

Results The results indicated that there is not any statistically relevant change (t-value < 2,011; $t_{(49,0.05)}$ / F< 4,0426; $F_{0.05(1,48)}$) in the alveolar bone density depending on the frequency of removable partial denture wearing.

Conclusion The frequency of removable partial denture wearing does not cause any changes in the alveolar bone density around the abutment teeth in the period of three-month denture wearing.

Key words*:* alveolar bone, removable denture, radiography

Corresponding author:
Kovačević Pavičić Daniela
Department of Prosthodontics,
School of Medicine, University of Rijeka
Krešimirova 40, 51000 Rijeka, Croatia
Phone: +385 51 345 633;
Fax: +385 51 345 630;
E-mail: daniela.kovacevic@medri.uniri.hr

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INTRODUCTION

The resorption of alveolar bone is a chronic, progressive disease of multifactorial etiology (1). This explicitly individual process depends on many local and systemic factors (2-11). The probability of alveolar bone resorption with removable partial denture (RPD) wearing increases due to the greater level of masticatory stress to the abutment teeth through occlusal rests, and through the supporting apparatus to the alveolar bone (5). The axial transmission of masticatory forces causes the compensatory thickening of the periodontal ligament of the teeth's supporting apparatus which through their pulling cause the apposition of cement and alveolar bone, that is, the increased density of the bone and specific bone trabeculae (12). On the other hand, oblique forces affect the teeth both pressure-wise and tensile-wise and are mostly concentrated on a small area and, also, exceed the limit of individual tolerance very quickly (12-14). They cause a disturbance in the circulation and a damage to the teeth's periodontal apparatus, and, consequently, lead to the reduction in the alveolar bone density (15-17). During mastication the clasps' function is to retain in the RPDs. The forces that appear in the process are non-physiological, but, also, inevitable. Thus, we assumed that the longer the effect of detrimental forces, the greater the resorption of alveolar bone should be (18). This lead us to examine whether wearing the partial dentures more frequently on a daily basis results in an increased resorption of alveolar bone. The literature data are not homogeneous. While some authors state that the frequency of wearing in great part affects the resorption of alveolar bone, others hold it irrelevant (18-20). Therefore, the aim of this research was to obtain a scientifically based evidence of the influence of the frequent RPD wearing on alveolar bone density around abutment teeth. The data gained will be applied in practice, that is, the patients will be advised to wear partial dentures 24 hours a day or only during the day.

The changes in the alveolar bone density are most easily estimated with serial radiographs. What needs to be achieved are the standardized conditions in which the radiographs will be recorded, that is, the differences in the X-radiation intensity, voltage and current need to be annulled, as well as the differences in the developing procedure and sensitivity of the film (21). Thus, calibration step wedges, varied in material and thickness, are used (22-24). They enable the conversion of different grey levels on scanned images into the equivalents of calibration step wedge thickness, and various mathematical methods are used to measure the difference in the bone density among several images of the same patient (25,26). The method is simple, fast and economical, and errors that might occur in the process are negligible and random (27).

EXAMINEES AND METHODS

Fifty examinees of both genders, wearing partial dentures, were included in the study (18 males and 32 females; 62.1 years old, median 64 years). Thirty-one examinees (62%) (31 examinees) of the examinees were wearing RPD for 24 hours a day, while 19 (38%) of them were wearing it only during day. The examinees were selected randomly among the patients that had arrived to the Prosthodontics Department of School of Dental Medicine, School of Medicine, University of Rijeka. The study was approved by the Ethical Committee of the School of Medicine and all the patients signed the informed consents.

The examined teeth were radiographed using the retroalveolar method twice in the time span of three months. The first time prior to the RPD delivery to the patient (for diagnostic purposes) and the second time after the three-month period of RPD wearing.

The radiographs were recorded under the same conditions using the ″EI-Niš″(Niš, Yugoslavia) X-ray device with the device voltage of 70 kV and constant current of 15 mA, at the exposure time of one s. ″Kodak Ultraspeed″ films (Eastman Rochester, N.Y.) were used for the recording. The films were developed in the automatic dark chamber Dur Dental Nova (Germany). A copper calibration step wedge consisting of five steps 0.1-0.5 mm thick was attached to every radiograph prior to the exposure. The step wedges were pasted onto the film margin in order not to cover the hard teeth and bone tissues. The films were scanned using the Umax Astra 3450 scanner with eight-bit resolution and 300 dpi. Seven Regions of interest (ROI) around the tooth root the size of ten pixels were chosen on each radiograph (Figure 1).

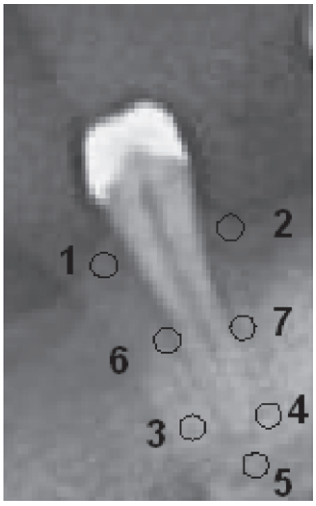

Figure 1. Seven regions of interest (ROI). ROI 1 – one mm mesially from the periodontal ligament at the level of the alveolar crest; ROI 2 – one mm distally from the periodontal ligament at the level of the alveolar crest; ROI 3 – one mm mesially from the periodontal ligament at the level of the apex of the tooth root; ROI 4 – one mm distally from the periodontal ligament at the level of the apex of the tooth root; ROI 5 – one mm apically from the periodontal ligament at the level of the apex of the tooth root; ROI 6 – one mm mesially from the midway between the distances of ROI 1 and ROI 3; ROI 7 – one mm distally from the midway between the distances of ROI 2 and ROI 4

The same ROIs were chosen on both radiographs. The ″Scion Image″ (Beta 4.0.2.) software and the third - degree polynomials as well as the Knezović-Zlatarić method were used to convert the grey levels into the copper calibration step wedge thickness equivalents (28). The equivalents were used to calculate the difference between two radiographs.

RESULTS

Taking into consideration sample particulars (number of examinees and RPD wearing distribution within the sample) one tail T-test for dependent patterns was used to analyze the possible difference in the alveolar bone density at various positions (ROI) for the entire sample. The level of reliability of the measurement was verified by the coefficient of variety (cv) which categorized the samples of the research as low-variance, with values less than 0.3 (variances do not differ significantly) what gave us confidence that our t-test is valid. The selected level of significance was p=0.05 (a significant result at the 95% probability level tells us that our data could support a conclusion with 95% confidence). We presumed this level of significance as being reasonable.

The results of this research have shown that all analyzed ROIs have the calculated t-values less than 2.011 which correspond with tabulated t for $t_{(49,0.05)}$. That means that results have not shown statistically significant difference in the alveolar bone density regarding the ROIs examined between the two radiographs recorded twice in the three–month time span (Table 1).

Table 1. Results of examined region of interest (between the first and the second radiograph in the three-month period after the beginning of removable partial dentures wearing) provided by Student t-test.

ROI	N	ROI A			ROI B			df	t
		X	s	cv	X	s	cv		
1	50	0,18509	0,05267	0,2846	0,17789	0,05262	0,2958	49	0,83927
2	50	0,13548	0,03974	0,2933	0,12910	0,03424	0,2652	49	0,67008
3	50	0,11972	0,03166	0,2644	0,11763	0,03431	0,2917	49	0,24413
4	50	0,19188	0,04886	0,2546	0,17566	0,04851	0,2762	49	1,36267
5	50	0,14761	0,03433	0,2326	0,14417	0,04067	0,2821	49	0,37172
6	50	0,16110	0,04358	0,2705	0,15897	0,04189	0,2635	49	0,21683
7	50	0,16056	0,03924	0,2444	0,14941	0,03907	0,2615	49	1,01825

ROI, Region of Interest; ROI A, Initial readings at ROI; ROI B, Readings after 3-months RPD wearing; N, sample; X, sample mean; s, population standard deviation; cv, coefficient of variance; df, degree of freedom; t, calculated t-test value

Furthermore, the one-way variance analysis was chosen to separate the substantiality of the differences in alveolar bone density in the ROI examined depending on the frequency of RPD wearing. The results confirmed that no statistically significant differences appeared in the alveolar bone density depending on the frequency of RPD wearing (wearing during daylight for 12 hours a day, or wearing for 24 hours a day) in the ROI examined in the given time span of three months. At same selected level of probability with p=0.05 all analyzed ROIs have variance ratio value (F-value) less than 4.0426 which correspond with tabulated F for $F_{0.05(1,48)}$) (Table 2) (Figure 2).

Table 2. Particulars of examined region of interest (between the first and the second radiograph in the three-month period after the beginning of removable partial dentures wearing) with appertaining ANOVA results

ROI	Between groups			Within groups			Total		F
DIFF	DFB	SSB	MSB	DFW	SSW	MSW	DFT	SST	
1	1	0,0025	0,0025	48	0,0865	0,0018	49	0,0889	1,3804
2	1	0,0016	0,0016	48	0,0894	0,0019	49	0,0910	0,8609
3	1	0,0004	0,0004	48	0,1530	0,0032	49	0,1534	0,1273
4	1	0,0002	0,0002	48	0,1622	0,0034	49	0,1624	0,0520
5	1	0,0003	0,0003	48	0,1232	0,0026	49	0,1235	0,0991
6	1	0,0010	0,0010	48	0,1487	0,0031	49	0,1496	0,3165
7	1	0,0003	0,0003	48	0,1871	0,0039	49	0,1874	0,0645

ROI DIFF, differences at positions of interest within 3 months period; DFB, degrees of freedom between groups; SSB, sum of squares between groups; MSB, mean square between groups; DFW, degrees of freedom within groups; SSW, sum of squares within groups; MSW, mean square within groups; DFT, total degrees of freedom; SST, total sum of squares; F, variance ratio

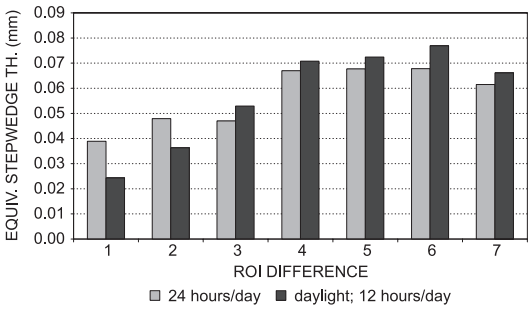

Figure 2. Changes of alveolar bone density (expressed in equivalents of copper step wedge) depending on removable partial dentures wearing.
Equiv. step wedge th, equivalents step wedge therapy

DISCUSSION

The alveolar bone is susceptible to changes during one's lifetime. Its resorption around the abutment tooth is an individual and complex process which can most simply and most economically be detected using serial radiographs (29,30). Still, since the loss of alveolar bone can be visually noticed only when it exceeds 30%, (31,32) we have opted for a computational estimate and calibration step wedges, which enable us to obtain the actual value of bone density converted into the calibration step wedge thickness equivalent at only 10% of bone loss (33).

The Knezović-Zlatarić method was chosen because in its research it has proven that the correlation coefficient with the third-degree polynomial function is close to one, which points to the large precision of the method (28).

Majority of the research into the changes in the alveolar bone density have been conducted under the base of the denture, but we believed it to be of great scientific and professional interest to determine the reaction of alveolar bone in the narrow area around the abutment tooth. RPD is a foreign body in the mouth, which during mastication affects the abutment tooth as a lever. Owing to that we expected that the bone resorption with the examinees that were wearing RDPs for 24 hours a day would be larger than with those who were wearing it occasionally. The literature data on the effect of frequent RPD wearing do not concur. Bargman and Kalk (18,19) in their research did not get any statistically relevant difference between the patients wearing RPDs for 24 hours a day and those wearing them only during day. Contrary to that, Xie (20) noticed a significantly larger bone resorption with patients that were wearing the RPDs for 24 hours a day.

Imai and Sato have explored this problem area with rats (34,35). While doing so they have proven that the constant pressure increases the alveolar bone resorption. However, the constant pressure is not physiological and this kind of situation does not occur in the mouth when the RPDs are properly planned, well retained and well-stabilized. Detrimental oblique forces affect the bone only when RPD is in function, that is, when masticating, which amounts to about 20 min a day. The rest of the day is the so called rest period during which the RPD with its clasps fits well to the abutment tooth not causing any pressure, and providing the opportunity for the alveolar bone to regenerate. Poorly retained and stabilized RPDs are, on the contrary, a constant irritation and additionally strain the abutment tooth and the supporting structures and can, thus, be expected that they will lead to a considerable alveolar bone resorption (5,15,16,36,37). A major issue, according to Čelebić et al. (38) is that the patients do not monitor their prostheses objectively and retain them even when important prosthetic factors (retention, stabilization, occlusion) are damaged. Our results have not shown any statistically relevant difference between the examined groups. It probably stems from the fact that we have examined the changes during a three-month period after the delivery of the prostheses when they were still completely satisfactory in terms of retention, stabilization and occlusion and did not lead to a significantly increased resorption. However, it should be noted that we have also noticed a positive trend of mild decrease in the alveolar bone density and it would be advisable to continue examining the changes in the bone longitudinally to determine whether over time more significant changes will occur or a functional equilibrium will be established.

It can be concluded that during the initial period of RPD wearing, after its delivery to the patient, there are no differences in the alveolar bone density between the patients who were wearing them for 24 hours a day and those who were wearing the RPDs only during the day.

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TRANSPARENCY DECLARATIONS

Competing interests: none to declare.

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Utjecaj nošenja djelomične proteze na resorpciju alveolarne kosti

Daniela Kovačević Pavičić[1], Vlatka Lajnert[1], Sunčana Simonić Kocijan[1], Ivone Uhač[1], Snježana Glavičić[2], Zoran Kovač[1]

[1]Katedra za stomatološku protetiku, [2]Katedra za endodonciju i restorativnu stomatologiju; Medicinski fakultet, Sveučilište u Rijeci, Rijeka, Hrvatska

SAŽETAK

Cilj Odrediti utjecaj učestalosti nošenja djelomične proteze na promjenu gustoće alveolarne kosti oko retencijskog zuba.

Metode Pedeset ispitanika, oba spola, nositelja djelomičnih proteza, bilo je uključeno u ovu studiju. Trideset i jedan ispitanik (62%) nosio je protezu 24 sata na dan, dok ju je 19 (38%) nosilo samo danju. Promjene u gustoći kosti oko retencijskog zuba određivane su metodom intraoralne mikrodenzitometrije. Standardne retroalveolarne rendgenske snimke su snimljene dva puta. Prva je snimljena prije predaje djelomične proteze, a druga nakon tri mjeseca njene uporabe. Bakreni klin, sačinjen od pet stepenica (0.1-0.5 mm), pričvršćen je na film u svrhu kalibriranja snimaka. Sedam točaka interesa, blizu korijena retencijskog zuba, veličine deset piksela, izabrano je na svakoj snimci. Siva polja u područjima interesa su izmjerena i pretvorena u ekvivalente debljine bakrenog klina radi utvrđivanja promjena u gustoći alveolarne kosti i mjerenja razlike u gustoći alveolarne kosti između dvaju snimaka.

Rezultati Rezultati ukazuju kako nema statistički značajne razlike u gustoći alveolarne kosti (t-value < 2,011; $t_{(49,0.05)}$ / F< 4,0426; $F_{0.05(1,48)}$) ovisno o učestalosti nošenja djelomične proteze.

Zaključak Učestalost nošenja djelomične proteze ne uzrokuje nikakve promjene u gustoći alveolarne kosti oko retencijskog zuba, tijekom tri mjeseca njene uporabe.

Ključne riječi*:* alveolarna kost, mobilna proteza, rendgenogram