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ORIGINAL SCIENTIFIC PAPER
IZVORNI ZNANSTVENI RAD

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Tooth-Implant-Supported Prosthetic Structures Versus Implant-Supported Restorations

Usporedba protetičkih radova implantat - zub ili implantat - implantat

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Abstract

Objectives: The primary aim was to compare the amount of bone height change that occurs around the tooth and the implant when having tooth-implant-supported prosthetic restorations versus bone height change that appears around implants in only implant-supported prosthetic restorations. The secondary aim was to examine the influence of various factors such as the number of teeth involved in the construction, their endodontic treatment, number of implants, the type of implantology construction, the jaw in which the construction is located, the condition of the opposite jaw, gender, age, and working time, as well as to examine whether the initial bone level influenced the amount of change in bone height itself. **Materials and methods**: With a total of 50 respondents, 25 X-ray panoramic images were representing tooth-implant-supported prosthetic restorations, while the other 25 were representing implant-supported prosthetic restorations. Bone measures were taken (from enamel-cement junction/implant neck to the most apical bone point) from 2 panoramic radiographs. The first one is immediately after the implant placement and the second and the last one again in half a year up to seven years after, depending on the time when the photo was taken for each patient. The obtained difference represented the bone resorption, the bone formation, or a state without change. Influence of different factors, such as sex, age of the patient, working time, the number of teeth involved in the construction, endodontic treatment, number of implants, the type of implant construction, the jaw where the construction is located, the condition of the opposite jaw, as well as the initial bone condition, was examined. During the statistical analysis, frequency tables, basic statistical parameters, the Mann-Whitney U test, the Kruskal-Wallis Anova, Wilcoxon test, and regression analysis were used, and the results were presented in tabular form and the form of the Pareto diagram of t-values. **Results**: No statistically significant difference in bone change (whether we are talking about the place of the implant (-0.359±1.009 and median value 0.000), the place of a tooth (-0.428±0.746 and median value -0,150) in tooth-implant supported restorations, or the place of the implant in case of implant-supported structures (-0,059±0,200 and median value -0,120)) was proven. When talking about the influence of other factors, by regression analysis, the number of implants was shown to be the only factor with a statistically significant influence (β=0.54; P=0.019) in a change of bone level, but only when talking about implant-supported restorations. **Conclusion**: No significant difference was proven between bone height change, neither around the tooth nor the implant in tooth-implant-supported prosthetic restorations compared to the bone height changes around the implant in only implant-supported prosthetic restorations. Among all the examined factors, the number of implants has shown to have statistically significant contribution to the amount of bone height change in implant-supported prosthetic restorations.

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Introduction

Bone remodeling is a lifelong process, during which it may happen that the bone formation and resorption of the bone substance are not always in balance. Generally, it can be said that alveolar bone loss increases with age. The mentioned changes, at least in part, can be related to the local factors, as well as the systemic conditions that encourage, either bone formation or bone resorption (1).

Alveolar bone is a tooth-dependent structure, with the loss of which the loss of periodontal ligament is brought about, which contributes to the reduction of the metabolism of the alveolar ridge.

Consequently, the masticatory force is transferred directly to the mucous membrane and bone, so the masticatory forces become compressive. The mentioned processes lead to further resorption of the residual ridge, which, although it gradually decreases, remains a constant and irreversible process (2).

To replace the missing tooth, a dental implant requires good osseointegration.

However, even the ones that are fixed in the bone by the process of osseointegration lack the periodontal ligament, which makes the biggest difference between teeth and the implant itself. Considering proprioceptive properties, support function, parafunctional load transfer, as well as the flexibility of the ligament itself, connecting teeth with implants, definitely represents a biomechanical challenge (3). There is a large number of those who believe that these types of connections are generally less likely to survive, because of the overloading of the implant on the one hand and intrusion of the tooth on the other.

Furthermore, the progression of the implant pathology showed to be particularly faster than the dental one, less controllable with endogenous molecules (4). The diagnosis of the pathology, whether made clinically or radiographically, is now an indication of full-blown and irreversible damage, which can be evaluated early with non-invasive instrumental research and represent a valid aid for prevention or early therapy (5).

When talking about multiple-implant connections, there are theories about reducing their load, as well as reducing bone loss, then reducing the chance of structural fracture of the implant, as well as the chance of loosening the screw (6).

The primary aim of this research was to compare the change in bone height that occurs in the place of a tooth and implant when having tooth-implant-supported prosthetic restorations versus only implant-supported prosthetic restorations. The secondary aims were to examine the influence of various factors such as the number of teeth involved in the construction, their endodontic treatment, the number of implants, the type of implantology construction, the jaw in which the construction is located, the condition of the opposite jaw, gender, age, working time, as well as to examine whether the initial bone level influenced the amount of change in bone height itself.

Uvod

Pregradnja kosti cjeloživotni je proces tijekom kojega se može dogoditi da formiranje i resorpcija koštane supstancije nisu uvijek u ravnoteži. Općenito se može reći da se gubitak alveolarne kosti povećava s dobi. Navedene promjene, barem djelomično, mogu se povezati s utjecajem lokalnih čimbenika, ali i sustavnih stanja koja potiču stvaranje ili resorpciju kosti (1).

Alveolarna kost struktura je ovisna o zubu čiji gubitak rezultira gubitkom parodontnoga ligamenta, pa se smanjuje metabolizam alveolarnog grebena. Posljedično se žvačna sila prenosi izravno na sluznicu i kost, čime žvačne sile postaju kompresijske. Navedeni procesi potiču daljnju resorpciju rezidualnog grebena koja, iako se postupno smanjuje, ostaje stalan i ireverzibilan proces (2).

Kako bi se nadomjestio zub koji nedostaje, zubni implantat zahtijeva dobru oseointegraciju. No čak i onim implantatima koji su procesom oseointegracije fiksirani u kost, nedostaje parodontni ligament, što upravo čini najveću razliku između zuba i samog implantata. Uzevši u obzir proprioceptivna svojstva, potpornu funkciju, prijenos parafunkcijskog opterećenja i fleksibilnost ligamenta, spajanje zuba s implantatima svakako je biomehanički izazov (3). Mnogi smatraju da se u slučaju ovakvog povezivanja može dogoditi preopterećenje implantata s jedne strane i intruzija zuba s druge strane, te da takvi radovi općenito slabije preživljavaju.

Nadalje, progresija patologije implantata pokazala se brža u odnosu prema dentalnoj te manje kontrolirana endogenim molekulama (4). Dijagnoza patologije, postavljena klinički ili radiografski, služi kao pokazatelj potpunoga i ireverzibilnoga oštećenja koje je, zato što može rano evaluirati neinvazivnim instrumentalnim pretragama, valjana pomoć za prevenciju ili pak ranu terapiju (5).

Kada govorimo o prednostima povezivanja više implantata, postoje teorije u kojima se ističe smanjenje njihova opterećenja i smanjenje gubitka koštane mase, zatim smanjenje mogućnosti strukturalne frakture implantata te popuštanje vijka (6).

Primarni cilj ovog istraživanja bio je usporediti promjenu visine kosti koja se pojavljuje na mjestu zuba i implantata kod protetičkih nadomjestaka postavljenih na zubima i implantatima i protetičkih nadomjestaka postavljenih samo implantatima. Sekundarni ciljevi bili su ispitati utjecaj različitih čimbenika kao što su broj zuba nosača, njihov endodontski tretman, broj implantata, vrsta implantološkog rada, čeljusti u kojoj se rad nalazi, stanje nasuprotne čeljusti, utjecaj spola, dobi i vremena nošenja, te ispitati je li početna razina kosti utjecala na daljnju promjenu visine kosti.

Materials and methods

This cross-sectional study, which was carried out in Salona Dental Polyclinic, is a pilot study, that will be serving as a basis for future studies. A total of 50 panoramic radiographs were used as input data, consisting of 25 radiographs with tooth-implant-supported prosthetic restorations, while the other 25 radiographs were implant-supported prosthetic restorations.

The patients were chosen under the condition of having an either tooth-implant-supported prosthetic restoration or an implant-supported prosthetic restoration, as well as the two panoramic radiographs (taken in different periods), since two panoramic radiograph measurements were performed during this study for each patient. The first measurement, used as a baseline, shows the height of the bone immediately after the implant was placed. The second and the last measurement, used as an endpoint, shows the height of the bone in the period from half a year to seven years after its placement, depending on the time when the second panoramic radiograph was taken. All implants belong to the Schütz-Dental-IMPLA, Rosbach vor der Höhe, Germany implant system.

Using the X-ray measuring tool (i-Dixel) from the Polyclinic, bone heights were measured, from the enamel-cement junction as a reference point for the tooth, or neck of the implant as a reference point for the implant to the most apical point of the bone. Research was conducted by 3 examiners, including a D.M.D. from Salona Dental Polyclinic, a student and a professor from the Medical University of Split, without prior calibration. The obtained difference between the bone heights represented the main result of the research, which, depending on whether it was negative, positive, or did not exist at all, represented bone resorption, bone gain, or a state without a change.

The research consisted of 21 men and 29 women with an average age of 58 years and average working time (time from implantation and first radiograph simultaneously to the last radiograph) of 1.6 years (56% of respondents with tooth-implant and implant-supported restorations had working time from 6 months up to 1 year, 24% of respondents with tooth-implant restorations and 20% of respondents with implant-supported restorations had working time from 1 to 2 years, 8% of respondents with tooth-implant restorations, and 20% of respondents with implant-supported restorations had working time from 2 to 4 years and 12% of respondents with tooth-implant restorations, as well as 4% of implant restorations had working time from 4 to 7 years. Different number of tooth and implants has been included, with an average of 2 teeth and 1 implant in tooth-implant-supported prosthetic restorations and 4 implants in implant-supported restorations. Besides the difference in numbers, when talking about tooth-implant-supported restorations, some of these teeth have been endodontically threatened (32%) and when talking about implant-supported restorations, 36% of the respondents have been wearing ''all on 4" structure, while the other 64% have been wearing a classic dental bridge. Furthermore, there is a difference in the jaw where prosthetic restora-

Materijal i metode

Ovo presječno istraživanje, koje je provedeno u poliklinici Salona Dental, jest pilot-istraživanje koje će poslužiti kao temelj za buduća istraživanja. Kao ulazni podatci koristilo se ukupno 50 radiografskih panoramskih snimki, od čega su na 25 bili protetički nadomjestci postavljeni na zubima i implantatima, a na ostalih 25 protetički nadomjestci postavljeni isključivo na implantatima. Pacijenti su birani pod uvjetom da imaju protetički nadomjestak nošen kombinacijom zuba i implantata ili postavljen samo implantatima i dvije radiološke panoramske snimke (snimljene u različitim razdobljima), jer su tijekom ove studije za svakog pacijenta obavljena dva panoramska radiografska mjerenja. Prvo mjerenje, koje se koristi kao početni pokazatelj, pokazuje visinu kosti neposredno poslije postavljanja implantata. Drugo, ujedno i posljednje mjerenje, koje se koristi kao krajnja točka, pokazuje visinu kosti u razdoblju od pola godine do sedam godina poslije postavljanja implantata, ovisno o vremenu snimanja druge panoramske snimke za svakog pacijenta. Svi implantati pripadaju sustavu Schütz-Dental-IMPLA, Rosbach vor der Höhe, Njemačka.

S pomoću radiološkog mjernog alata (i-Dixel) poliklinike izmjerene su visine kosti, počevši od caklinsko-cementnoga spoja kao referentne točke za zub, odnosno vrata implantata kao referentne točke za implantat, sve do najapikalnije točke kosti. Istraživanje su, bez prethodne kalibracije, provela tri ispitivača, među kojima su sudjelovali dr. med. dent. iz poliklinike Salona Dental, student i profesor Medicinskog fakulteta u Splitu. Dobivena razlika u visini kostiju bila je glavni rezultat istraživanja koja je, ovisno o tome je li negativna, pozitivna ili je uopće nije bilo, predstavljala resorpciju kosti, prirast kosti ili pak stanje bez promjene.

U istraživanju je sudjelovao 21 muškarac i 29 žena prosječne dobi od 58 godina i prosječnog vremena nošenja (vrijeme od implantacije i prve radiološke snimke istodobno pa do posljednje radiološke snimke) od 1,6 godina (56 % ispitanika sa zubom-implantatom postavljenim na restauracijama i implantatima postavljenim na restauracijama imalo je vrijeme nošenja od 6 mjeseci do 1 godine, 24 % ispitanika sa zubom-implantatom postavljenim na restauracijama i 20 % ispitanika s implantatima na restauracijama imalo je vrijeme nošenja od 1 do 2 godine, 8 % ispitanika sa zubom-implantatom postavljenim na restauracijama i 20 % ispitanika s implantatima postavljenima na restauracijama imalo je vrijeme nošenja od 2 do 4 godine, a 12 % ispitanika sa zubom-implantatom postavljenim na restauracijama, te 4 % restauracija na implantatima imalo je vrijeme nošenja od 4 do 7 godina). Uključen je različit broj zuba i implantata, s prosječno dvama zubima i jednim implantatom u protetičkim nadomjescima postavljenima na zubima i implantatima i četirima implantatima u nadomjescima postavljenima samo na implantatima. Osim razlike u brojevima kada je riječ o restauracijama na zubima i implantatima, neki od tih zuba bili su endodontski tretirani (32 %), a kada je riječ o implantatima postavljenima na restauracijama, 36 % ispitanika imalo je ''all on 4" konstrukcije, a ostalih 64 % klasični most. Nadalje, postoji razlika u čeljusti u kojoj je protetički nadomjestak,

tion is located, as well as in the condition of the opposite jaw. In tooth-implant-supported prosthetic restorations, 44% of restorations are located in the upper and 56% of them are located in the lower jaw, while in implant-supported restorations, 80% of restorations are located in the upper and 20% of restorations are located in the lower jaw. In tooth-implant-supported restorations, 44% of restorations have had natural dentition as an antagonist, and 56% of them have had metal-ceramic antagonists. In implant-supported restorations, 32% of restorations have had natural dentition as the antagonist, while the other 68% of them have had metal-ceramic as the antagonist. Some of the responses also showed the presence of periodontal (12% of teeth in tooth-implant-supported restorations) or peri-implant (22% of implants in tooth-implant and 18% in implant-supported restorations) diseases, marked as negative initial bone condition.

STATISTICA 11.0 package was used for statistical data processing, including basic statistical parameters, frequency tables, the Mann-Whitney, and the Kruskal-Wallis Anova, as well as the multiple comparison tests, the Wilcoxon matched pairs test, and a general regression model that examines the influence of predictor variables. Statistical significance was reduced to P<=0.05.

Results

Change in bone height (Table 1), expressed as the difference between the initial and final state, was greater in the case of a tooth-implant connection, whether we are talking about the bone around the implant (-0.359±1.375 and median value 0,000), or around a tooth (-0.428±0.746 and median value -0.150), then it was around the implant in the case of implant-supported structures (- 0.059±0.200 and median value -0.120). Bone changes expressed in percentages had these values: 21.8% at the place around the tooth, 24.2% at the place around the implant in case of tooth- implant-supported restorations and 10.8% at the place around the implant in case of the implant-supported restorations (Table 2). However, the mentioned changes were not proven to be statistically significant.

kao i u stanju nasuprotne čeljusti. Kod protetičkih nadomjestaka na zubima i implantatima 44 % nadomjestaka nalazi se u gornjoj čeljusti, a 56 % u donjoj, a na implantatima postavljenima na restauracijama 80 % nadomjestaka nalazi se u gornjoj čeljusti, a 20 % u donjoj. U restauracijama postavljenima na zubima i implantatima, 44 % restauracija imalo je prirodnu denticiju kao antagonista, a 56 % metal-keramiku. Kod nadomjestaka postavljenih na implantatima, 32 % nadomjestaka imalo je prirodnu denticiju kao antagonista, a ostalih 68 % metal-keramiku. Neki od ispitanika imali su također parodontne (12 % zuba u nadomjescima na zubima i implantatima) ili periimplantantne bolesti (22 % implantata u nadomjescima na zubima i implantatima i 18 % u nadomjescima potpomognutim implantatima) označene kao negativno početno stanje kosti.

Za statističku obradu podataka korišten je paket STATISTICA 11.0, uključujući osnovne statističke parametre, tablice učestalosti, Mann-Whitneyjev test i Kruskal-Wallisovu ANOVA-u, test višestruke usporedbe, Wilcoxonov test uparenih parova i opći regresijski model koji ispituje utjecaj prediktorskih varijabli. Statistička značajnost svedena je na P < = 0,05.

Rezultati

Promjena visine kosti (tablica 1.), izražena kao razlika između početnog i završnog stanja, bila je veća u slučaju spoja zub-implantat, bilo da je riječ o kosti oko implantata (-0,359±1,375 i vrijednost medijana 0,000) ili oko zuba (-0,428±0,746 i medijan vrijednosti -0,150), nego oko implantata u slučaju da je postavljen na strukturama (-0,059±0,200 i medijan vrijednosti -0,120). Koštane promjene izražene u postotcima imale su sljedeće vrijednosti: 21,8 % na mjestu zuba, 24,2 % na mjestu implantata u slučaju nadomjestaka postavljenih na zubu i implantatu i 10,8 % oko implantata u slučaju nadomjestaka postavljenih samo na implantatu (tablica 2.) Međutim, navedene promjene nisu se pokazale statistički značajnima.

Table 1 Basic statistical parameters for change in bone height around teeth and implants after prosthetic provision, in constructions which were either implant-supported or where the supports were both tooth and implant, in period from half a year up to 7 years
Tablica 1. Osnovni statistički parametri za promjenu visine kosti oko zuba i implantata poslije protetičke opskrbe konstrukcija postavljenih na implantate ili na kombinacije zuba i implantata u razdoblju od pola godine do 7 godina

	Change in • Promjena na mjestu	åX[a]	SD[b]	Min	Max	M[c]	P*
Initial state • Početno stanje	Implant • impl.	-1.125	1.468	-5.930	0.000	-0.840	0.039†
	Implant-Supported restor. • impl. nošene konstruk.	-0.487	0.732	-2.100	0.000	0.000	
	Tooth • zub	-1.533	1.122	-2.810	0.130	-1.805	
Final state • Konačno stanje	Implant • impl.	-1.484	1.784	-6.790	0.725	-1.180	0.012†
	Implant-Supported restor. • impl. nošene konstruk.	-0.546	0.738	-2.220	0.000	-0.212	
	Tooth • zub	-1.961	1.375	-3.610	0.173	-2.260	
Change • Promjena	Implant • impl.	-0.359	1.009	-2.570	1.000	0.000	0.239
	Implant-Supported restor. • impl. nošene konstruk.	-0.059	0.200	-0.627	0.375	-0.120	
	Tooth • zub	-0.428	0.746	-1.870	0.305	-0.150	

* stat. significance as a result of Mann-Whitney U test • stat. značenje kao rezultat Mann-Whitneyjeva U testa
† stat. significant at the significance level $P<0,05$ • stat. značajna na razini značajnosti $P < 0,05$
[a] mean value • srednja vrijednost
[b] standard deviation • standardna devijacija
[c] median • medijan

Table 2 Percentage of change in bone height around tooth and implant after prosthetic provision, where the supports of prosthetic construction were tooth and implant compared to those constructions which were implant-supported.
Tablica 2. Postotak promjene visine kosti oko zuba i implantata poslije protetičke opskrbe konstrukcija postavljenih na implantate u usporedbi s konstrukcijama postavljenima na kombinacije zuba i implantata.

Change in • Promjena na mjestu	Mean value of change (%)	*P**
Implant • impl.	24.2	0.237
Tooth • zub	21.8	
Implant-Supported restorations • impl.nošene konstr.	10.8	

* stat. significance as a result of Mann-Whitney U test • stat. značenje kao rezultat Mann-Whitneyjeva U testa

Table 3 Change in bone height in constructions supported by tooth and implant depending on the place where change occurs
Tablica 3. Promjena visine kosti kod konstrukcija postavljenih na zube i implantate, ovisno o mjestu promjene

Change in • Promjena na mjestu	N (%)	åX[a]	SD[b]	Min	Max	M[c]	*P**
Implant • Impl.	11 (44)	-0.669	1.120	-2.570	1.000	-0.240	0.384
Tooth • Zub	4 (16)	-0.523	1.102	-1.870	0.740	-0.482	
No change • Bez promjene	5 (20)	0.000	0.000	0.000	0.000	0.000	
Both • Oboje	5 (20)	-0.017	0.643	-1.004	0.725	0.043	

* stat. significance as a result of Kruskal-Wallis Anova test
[a] mean value • srednja vrijednost
[b] standard deviation • standardna devijacija
[c] median • medijan

Comparing the place where a change in bone height occurred most often in tooth-implant- supported restorations, it is obvious from Table 3 that 44% of changes in bone height occurred only around the implant, 16% only around a tooth, and in 20% of cases changes were seen around both, the tooth and the implant, while in the other 20% of cases, no changes were visible at all.

The biggest bone resorption is seen around the implant (-0.669±1.120) and then around a tooth (- 0.523±1.102), while the smallest changes, both at the place of tooth and implant, occurred when both the tooth and the implant were affected by the loss, but none of them did show any statistical significance.

Considering the different number of teeth involved in the construction, although the biggest bone resorption around the implant is confirmed when 5 carrier teeth were involved in tooth-implant connection (-0.766±1.118 and median value -0.354), no statistical significance was confirmed concerning groups with different numbers of teeth involved. Some of the carrier teeth also underwent endodontic treatment, specifically 8 from 25 (32%). Although implants connected with endodontically treated teeth show 66.9% greater bone resorption values (-0.654±1.245) when compared to those which were not connected (-0.199±0.879) with endodontically treated teeth, differences are not statistically significant. The same thing was proven in bone resorption around the tooth which is 78.5% higher, but still statistically insignificant compared to the ones that did not undergo endodontics.

Regarding the difference in the number of implants involved in work, with prosthetic constructions supported by tooth and implant, the biggest resorption on the place of the implant is confirmed in the case of 2 implants (-0.844±1.174), while with prosthetic constructions supported exclusively by implants, the biggest resorption has been confirmed in case of 4 implants (- 0.158±0.212). There was no statistical sig-

Uspoređujući mjesto na kojem se najčešće događala promjena visine kosti kod nadomjestaka postavljenih na zubima i implantatima, vidljivo je iz tablice 3. da se 44 % promjena visine kosti dogodilo na mjestu implantata, 16 % na mjestu zuba, 20 % promjena vidljivo je i na mjestu i zuba i implantata, a u ostalih 20 % slučajeva nisu bile vidljive nikakve promjene. Najveća resorpcija kosti vidljiva je oko implantata (-0,669±1,120) i oko zuba (-0,523±1,102), a najmanje promjene, i na mjestu zuba i implantata, nastale su kada su gubitkom bili zahvaćeni i zub i implantat, ali svi oni nisu pokazali nikakvu statističku značajnost.

S obzirom na različit broj zuba uključenih u rad, iako je najveća resorpcija kosti oko implantata potvrđena kada je 5 zuba nosača bilo uključeno u vezu zub-implantat (-0,766±1,118 i medijan vrijednosti -0,354), nije potvrđena statistička značajnost u odnosu prema skupini s različitim brojem uključenih zuba. Neki od zuba nosača također su bili podvrgnuti endodontskom liječenju, točnije 8 od 25 (32 %). Iako implantati povezani s endodontski liječenim zubima pokazuju 66,9 % veće vrijednosti resorpcije kosti (-0,654±1,245) u usporedbi s onima koji nisu vezani (-0,199±0,879) s endodontski liječenim zubima, razlike nisu statistički značajne. Isto je dokazano i u slučju resorpcije kosti oko zuba koja je 78,5 % veća, ali još uvijek statistički beznačajna u usporedbi s onima koji nisu bili podvrgnuti endodonciji.

S obzirom na razliku u broju implantata uključenih u rad, kod protetičkih konstrukcija postavljenih na zub i implantat najveća resorpcija na mjestu implantata potvrđena je u slučaju 2 implantata (-0,844±1,174), a kod onih isključivo na implantatima, potvrđena je u slučaju 4 implantata (-0,158±0,212). Nije potvrđena statistička značajnost između navedenih skupina (tablica 4.). Postoji i razlika u vrsti implantološkog rada, pa je tako kod klasičnoga mosta otkriven koštani rast (0,036±0,188), a kod „all-on-4" dogodila se re-

Table 4 Frequency and basic statistical parameters for bone height change around implant after prosthetic provision, in constructions which were either implant-supported or where the supports were both tooth and implant, depending on the number of implants.
Tablica 4. Učestalost i osnovni statistički parametri za promjenu visine kosti oko implantata poslije protetičke opskrbe konstrukcija postavljenih na implantate ili na kombinacije zuba i implantata, ovisno o broju implantata.

Change in • Promjena na mjestu	No. of implants	N	`X[a]	SD[b]	Min	Max	M[c]	P*
Implant • Impl.	1	13	-0.210	0.954	-2.400	1.000	0.000	0,573
	2	4	-0.844	1.174	-2.570	0.000	-0.402	
	3	0						
	4	0						
	5	0						
	6	0						
	8	0						
Implant-Supported restor. • Impl. nošene konstr.	1	0						
	2	7	0.088	0.196	-0.120	0.375	0.000	
	3	0						
	4	10	-0.158	0.212	-0.627	0.000	-0.058	
	5	3	0.000	0.000	0.000	0.000	0.000	
	6	4	-0.117	0.135	-0.250	0.000	-0.108	
	8	1	-0.035	0.000	-0.035	-0.035	-0.035	

* stat. significance as a result of Kruskal-Wallis Anova test
[a] mean value • srednja vrijednost
[b] standard deviation • standardna devijacija
[c] median • medijan

nificance confirmed between these mentioned groups (Table 4). There is also a difference regarding the type of implant work, so with the classic bridge, bone growth was discovered (0.036±0.188), while in All-on-4 there was a bone resorption (-0.122±0.187). However, this difference did not show any statistical significance, either.

When comparing the impact of the jaw in which the construction is located, changes in the upper jaw go in the following sequence: at the place of the implant in the tooth-implant connection, at the place of the tooth in the tooth-implant connection, at the place of the implant for prosthetic structures supported only by implants, while in the lower jaw changes go in this sequence: at the place of the tooth in tooth-implant connection, at the place of the implant in tooth-implant connection, at the place of implant-supported structures. Regarding the state of the antagonistic jaw, changes in bone height around the implant in tooth-implant connection are 66.3% higher in the case of the antagonistic jaw with metal-ceramic compared to natural teeth. On the other hand, the situation is opposite in changes at the place of tooth, they are 54.6% higher when natural teeth are antagonists. Changes in cases where carriers were exclusively implants are 11.1% higher in those situations where an antagonistic jaw was a metal-ceramic construction. No statistically significant difference was proven between the mentioned groups, including the state of antagonistic jaws, or between the jaws in which the construction is located.

Negative bone changes showed to be less seen in men than in women (Table 5), except at the place of the implant in case of tooth-implant connection where resorption for men showed to be 43.6% higher than for women. At the place of the tooth in the tooth-implant connection, resorption for women showed to be higher at 87.8%, the same

sorpcija kosti (-0,122±0,187). No ni ta razlika nije pokazala nikakvu statističku značajnost.

Uspoređujući utjecaj čeljusti u kojoj se nalazi konstrukcija, promjene u gornjoj čeljusti kreću se sljedećim redoslijedom: na mjestu implantata kod spoja zub-implantat, na mjestu zuba kod spoja zub-implantat, na mjestu implantata kod protetičkih konstrukcija postavljenih samo na implantate, a u donjoj čeljusti promjene idu ovim redoslijedom: na mjestu zuba kod spoja zub-implantat, na mjestu implantata kod spoja zub-implantat, na mjestu implantata kod implantatima nošenih struktura. Kad je riječ antagonističkoj čeljusti, promjene u visini kosti oko implantata kod spoja zub-implantat veće su za 66,3 % kod antagonističke čeljusti s metal-keramikom u odnosu prema prirodnim zubima. S druge strane, situacija je suprotna u promjenama na mjestu zuba, gdje su promjene za 54,6 % veće kada su antagonisti prirodni zubi. Promjene u slučaju kada su nositelji bili isključivo implantati veće su za 11,1 % ako je u antagonističkoj čeljusti bila metal-keramička konstrukcija. Nije dokazana statistički značajna razlika između navedenih skupina, uključujući stanje antagonističkih čeljusti, ni između čeljusti u kojima se nalazi konstrukcija.

Negativne koštane promjene bile su manje kod muškaraca u odnosu prema ženama (tablica 5.), osim na mjestu implantata u slučaju spoja zuba i implantata gdje je resorpcija kod muškaraca bila 43,6 % veća nego kod žena. Na mjestu zuba kod spoja zub-implantat resorpcija je kod žena bila veća za 87,8 % kao i kod implantatima nošenih struktura kod kojih je bila veća za 98,3 %. No navedene promjene nisu statistički značajne. U različitim dobnim skupinama (tablica 6.), iako statistički beznačajno, pokazalo se da je resorpcija kosti na mjestu implantata u spoju zub-implantat povećana u dobi od 30 do 50 godina (-1,200±1,697), nakon čega

Table 5 Frequency and basic statistical parameters for bone height change around tooth and implant after prosthetic provision, in constructions which were either implant-supported or where the supports were both tooth and implant, depending on the gender.
Tablica 5. Učestalost i osnovni statistički parametri za promjenu visine kosti oko zuba i implantata poslije protetičke opskrbe konstrukcija postavljenih na implantate ili na kombinaciju zuba i implantata, ovisno o spolu.

Gender • Spol	Change in • Promjena na mjestu	N (%)	`X[a]	SD[b]	Min	Max	M[c]	P*
Men • M	Implant • Impl.	3 (14)	-0.560	0.970	-1.680	0.000	0.000	0.654
	Tooth • Zub	5 (24)	-0.116	0.526	-1.004	0.305	0.043	
	Implant-Supported rest. • Impl. nošene konstr.	13 (62)	-0.002	0.193	-0.255	0.375	0.000	
Women • Ž	Implant • Impl.	14 (48)	-0.316	1.047	-2.570	1.000	-0.100	
	Tooth • Zub	3 (11)	-0.949	0.864	-1.870	-0.156	-0.820	
	Implant-Supported rest. • Impl. nošene konstr.	12 (41)	-0.120	0.197	-0.627	0.000	0.000	

* stat. significance as a result of Kruskal-Wallis Anova test
[a] mean value • srednja vrijednost
[b] standard deviation • standardna devijacija
[c] median • medijan

Table 6 Frequency and basic statistical parameters for bone height change around tooth and implant after prosthetic provision, in constructions which were either implant-supported or where the supports were both tooth and implant, depending on the age.
Tablica 6. Učestalost i osnovni statistički parametri za promjenu visine kosti oko zuba i implantata poslije protetičke opskrbe konstrukcija postavljenih na implantate ili na kombinacije zuba i implantata, ovisno o dobi.

Change in • Promjena na mjestu	Age	N (%)	`X[a]	SD[b]	Min	Max	M[c]	P*
Implant • Impl.	30-40	3 (6)	-0.685	1.698	-2.570	0.725	-0.210	0.256
	40-50	2 (4)	-1.200	1.697	-2.400	0.000	-1.200	
	50-60	4 (8)	-0.319	0.474	-0.860	0.150	-0.282	
	60-70	7 (14)	-0.160	0.790	-1.680	1.000	0.000	
	70+5	1 (2)	0.740	0.000	0.740	0.740	0.740	
Implant-Supported rest. • Impl. nošene konstr.	30-40	2 (4)	-0.060	0.085	-0.120	0.000	-0.060	
	40-50	4 (8)	0.184	0.212	0.000	0.375	0.180	
	50-60	9 (18)	-0.167	0.225	-0.627	0.000	0.000	
	60-70	8 (16)	-0.072	0.096	-0.217	0.000	-0.018	
	70+5	2 (4)	0.000	0.000	0.000	0.000	0.000	
Tooth • Zub	30-40	0						
	40-50	0						
	50-60	3 (6)	-0.945	0.870	-1.870	-0.144	-0.820	
	60-70	5 (10)	-0.118	0.526	-1.004	0.305	0.043	
	70+5	0						

* stat. significance as a result of Kruskal-Wallis Anova test
[a] mean value • srednja vrijednost
[b] standard deviation • standardna devijacija
[c] median • medijan

as in implant-supported structures in which it is higher for 98.3%. However, the mentioned changes are not statistically significant. In different age groups (Table 6), although statistically insignificant, it was shown that bone resorption at the place of the implant in the tooth-implant connection is increased from the ages 30 to 50 (-1.200±1.697), after which it is decreased, and then after the age of 70 bone growth occurs (0.740±0.000). When we talk about changes at the place of the tooth in tooth-implant connection, the biggest resorption happens between the ages of 50 and 60 years (- 0.945±0.870), after which it also decreases. In the case where the carriers were exclusively implants, the biggest resorption also happens between the ages of 50 and 60 (-0.167±0.225), while bone growth was confirmed between 40 and 50 (0.184±0.212).

se smanjuje, a zatim se poslije 70. godine događa prirast kosti (0,740±0,000). Kada govorimo o promjenama na mjestu zuba kod spoja zub-implantat, najveća je resorpcija u dobi između 50. i 60. godine (-0,945±0,870), nakon čega se također smanjuje. U slučaju kada su nosači bili isključivo implantati, najveća resorpcija također se događa u dobi između 50 i 60 godina (-0,167±0,225), a prirast kosti potvrđen je između 40. i 50. godine (0,184±0,212).

Kad je riječ o vremenu nošenja (tablica 7.), na mjestu implantata kod spoja zub-implantat najveća se resorpcija kosti uočava nakon 1 do 2 godine nošenja (-1,023±1,425), a u razdoblju od 4 do 7 godina pojavljuje se prirast kosti (0,740). U slučaju resorpcije na mjestu zuba kod spoja zub-implantat najveća se vrijednost također primjećuje nakon 1 do 2 godine (-1,345±0,742), a prirast kosti nastaje poslije 2 do 4 godine,

Table 7 Frequency and basic statistical parameters for bone height change around tooth and implant after prosthetic provision, in constructions which were either implant-supported or where the supports were both tooth and implant, depending on the time of carrying it.
Tablica 7. Učestalost i osnovni statistički parametri za promjenu visine kosti oko zuba i implantata poslije protetičke opskrbe konstrukcija postavljenih na implantate ili na kombinacije zuba i implantata, ovisno o vremenu nošenja.

Change in • Promjena na mjestu	Time (year)	N (%)	`X[a]	SD[b]	Min	Max	M[c]	P*
Implant • Impl.	0.5-1	12 (48)	-0.230	0.799	-2.400	1.000	0.000	0.322
	1-2	4 (32)	-1.023	1.425	-2.570	0.725	-1.123	
	2-4	0 (0)						
	4-7	1 (4)	0.740	0.000	0.740	0.740	0.740	
Tooth • Zub	0.5-1	2 (8)	-0.150	0.008	-0.156	-0.144	-0.150	
	1-2	2 (8)	-1.345	0.742	-1.870	-0.820	-1.345	
	2-4	2 (8)	0.263	0.060	0.220	0.305	0.263	
	4-7	2 (8)	-0.480	0.741	-1.004	0.043	-0.480	
Implant-supported rest. • Impl. nošene konstr.	0.5-1	14 (56)	-0.074	0.225	-0.627	0.360	0.000	
	1-2	5 (20)	-0.066	0.098	-0.217	0.000	0.000	
	2-4	5 (20)	-0.094	0.129	-0.255	0.000	0.000	
	4-7	1 (4)	0.375	0.000	0.375	0.375	0.375	

* stat. significance as a result of Kruskal-Wallis Anova test
[a] mean value • srednja vrijednost
[b] standard deviation • standardna devijacija
[c] median • medijan

Table 8 Frequency and basic statistical parameters for bone height change around tooth and implant after prosthetic provision, in constructions which were either implant-supported or where the supports were both tooth and implant, depending on the initial state.
Tablica 8. Učestalost i osnovni statistički parametri za promjenu visine kosti oko zuba i implantata poslije protetičke opskrbe konstrukcija postavljenih na implantate ili na kombinaciju zuba i implantata, ovisno o početnom stanju.

Change in • Promjena na mjestu	Initial state • Početno stanje	N (%)	`X[a]	SD[b]	Min	Max	M[c]	P*
Implant • Impl.	Resorption • Resorpcija	11 (22)	-0.199	0.928	-2.570	1.000	0.000	0.503
	No change • Bez promjene	6 (12)	-0.653	1.172	-2.400	0.725	-0.282	
	Growth • Rast	0 (0)						
Implant-Supported rest. • Impl. nošene kosntr.	Resorption • Resorpcija	9 (18)	-0.046	0.304	-0.627	0.375	-0.035	
	No change • Bez promjene	16 (32)	-0.065	0.121	-0.367	0.000	0.000	
	Growth • Rast	0 (0)						
Tooth • Zub	Resorption • Resorpcija	6 (12)	-0.442	0.839	-1.870	0.305	-0.150	
	No change • Bez promjene	1 (2)	-0.820	0.000	-0.820	-0.820	-0.820	
	Growth • Rast	1 (2)	0.043	0.000	0.043	0.043	0.043	

* stat. significance as a result of Kruskal-Wallis Anova test
[a] mean value • srednja vrijednost
[b] standard deviation • standardna devijacija
[c] median • medijan

Regarding the duration of working time (Table 7), at the place of the implant in tooth-implant connection, the biggest bone resorption is noticed after 1-2 years of wearing (-1.023±1.425), while bone growth occurs (0.740) in 4-7 years. In the case of resorption at the place of the tooth in the tooth-implant connection, the highest value is also noticed after 1-2 years (- 1.345±0.742), and bone growth occurs after 2 to 4 years, after which resorption follows again. In implant-supported structures, bone resorption increases with wearing duration, until the 4th year occurs, and then it is followed by bone growth from the 4th to 7th year of wearing. However, statistically significant difference was not proven.

Another statistically insignificant difference was shown when observing levels of resorption regarding the negative

nakon čega ponovno slijedi resorpcija. U strukturama nošenim implantatima, resorpcija kosti raste s vremenom nošenja, sve do 4. godine, a zatim slijedi prirast kosti od 4. do 7. godine nošenja. Statistički značajna razlika među navedenim skupinama nije dokazana.

Još jedna statistički neznatna razlika uočena je promatranjem razina resorpcije u odnosu prema negativnom početnom stanju koja se pokazala najvećom na mjestu zuba kod spoja zuba i implantata (-0,442±0,839 i vrijednost medijana -0,150), a najmanjom u slučaju kada su nositelji protetičke konstrukcije bili isključivo implantati (-0,046±0,304 i vrijednost medijana -0,035) (tablica 8.)

Ispitivanjem utjecaja prediktorskih varijabli na promjenu visine kosti korištenjem regresijske analize, kod protetič-

Table 9 Results of regression analysis for implant-supported constructions depending on the predictor variables.
Tablica 9. Rezultati regresijske analize za konstrukcije postavljene isključivo na implantate, ovisno o prediktorskim varijablama

Predictor (N=25) • Prediktor	Regression coefficient (β[a])	*P**
Connection • Vrsta veze	0.24	0.137
Time • Vrijeme nošenja	0.17	0.249
Jaw • Čeljust	0.02	0.868
Number of implants • Br. impl.	0.54	0.019†
Gender • Spol	0.33	0.107
Age • Dob	0.09	0.548
		R[b]=0.45; *P*=0.049†

* stat. significance as a result of regression analysis
† stat. significant at the significance level $P<0,05$
[a] individual contribution of each variable to the total correlation
[b] correlation coefficient

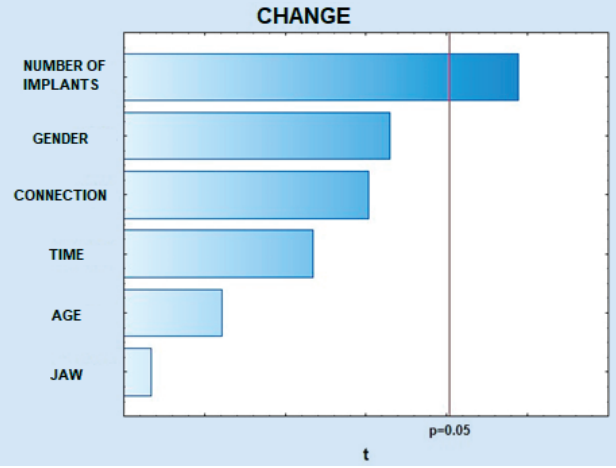

Image 1 Pareto chart of t-values for dependence of change in bone height around the implant after prosthetic provision, where the carriers of construction were exclusively implants in dependence of predictor variables. Variables that cross the red line have a statistically significant contribution.
Slika 1. Paretov dijagram t-vrijednosti za ovisnost promjene visine kosti oko implantata poslije protetičkog postavljanja – nositelji konstrukcije bili su isključivo implantati u ovisnosti o prediktorskim varijablama; varijable koje prelaze crvenu crtu imaju statistički značajan doprinos

initial state, which showed to be the biggest at the place of the tooth in the tooth-implant connection (-0.442±0.839 and median value -0.150), and the lowest in the case where prosthetic construction carriers were exclusively implants (-0.046±0.304 and median value -0.035) (Table 8).

Examining the impact of predictor variables on bone height change using regression analysis, in implant-supported prosthetic restorations (Table 9, image 1) one statistically significant correlation has been confirmed (R=0.45; P=0.049). From beta coefficient values, their significance, and the Pareto diagram of t-values, it is visible that the number of implants is the only variable with a statistically significant impact in total correlation (β=0.54; P=0.019), while all other predictor variables were insignificant, or they had large dispersion on a small sample size and for that reason were not suitable for measurement.

Discussion

Research published by Albrektsson et al. (1986) also states that after the placement of the implant itself, resorption of the surrounding bone should occur, with the difference that resorption should be less than 1.5 mm in the first year and should increase by 0.2 mm every subsequent year. The results of this research show that resorptive changes at the place of implant dominate for a certain period, where after about 4-7 years a period of bone growth follows (7).

kih nadomjestaka postavljenih na implantate (tablica 9., slika 1.) potvrđena je jedna statistički značajna korelacija (R=0,45; P=0,049). Iz vrijednosti ß-koeficijenata, njihove značajnosti i Paretova dijagrama t-vrijednosti, vidljivo je da je broj implantata jedina varijabla sa statistički značajnim utjecajem u ukupnoj korelaciji (β = 0,54; P = 0,019), a sve ostale prediktorske varijable bile su beznačajne ili su pak imale veliku disperziju na malom uzorku i zbog toga nisu bile prikladne za mjerenje.

Rasprava

U istraživanju koje su objavili Albrektsson i suradnici (1986.), također se zaključuje da poslije ugradnje implantata nastaje resorpcija okolne kosti, s tom razlikom da bi resorpcija trebala biti manja od 1,5 mm u prvoj godini i trebala bi se povećavati za 0,2 mm svake sljedeće godine. Rezultati ovog istraživanja pokazuju da u određenom razdoblju dominiraju resorptivne promjene na mjestu implantata, a poslije otprilike 4 do 7 godina slijedi razdoblje prirasta kosti (7).

When speaking about the differences in average bone resorption at different places, this research is in line with the research conducted by Hosny et al. (2000), in which it was also concluded that there was no difference in bone change at the place of the implant when comparing tooth-implant and implant-supported structures. In their work, a loss of 1 mm in the first half of the year was described, followed by an annual shift of 0.015 mm over the next 14 years. Similar conclusions were conducted in studies done by Gunne et al. (1999) and Lindh et al. (2001) (8-10).

A statistically significant difference in bone height change depending on the number of the carrier teeth were not proven, in contrast to the number of implants, which was shown by regression analysis as a predictor variable with a statistically significant contribution to the change in bone height around the implant in case of an implant-supported structure. Tabrizi et al. did not prove the relationship between the number of implants and its impact on bone loss, as statistically important, which would suggest against the above-mentioned results that were proven by regression analysis (11).

Out of those studies that deal with the connection between endodontically treated teeth in the tooth-implant connection regarding the bone change, the one by Lindh et al. (2001) and Block et al. (2002) should be singled out. Lindh et al. did not show a statistically significant impact of endodontic treatment on the change in bone height neither around the tooth nor around the implants connected to it, as is shown in this study also, while Block et al., on the other hand, showed conflicting results in the place of the carrier tooth, previously treated with a root canal therapy (10,12).

For the influence of the type of implantological construction on the amount of bone height change around the implant, the statistically significant difference on this matter was not proven by Malo et al. (2011), nor by Babbush et al. (2011), whose conclusions also suggest that the difference in bone height change was not shown as statistically significant depending on whether it was a case with a classic bridge or an All-on-4 construction (13,14).

While in this study a statistically significant influence of the jaw in which construction is located, was not proven on the change in bone height, in the study conducted by Negri et al. (2014), in male patients with the upper jaw as the carrier of work, the change increases in correlation with their age, while in situations where the carrier of construction is the lower jaw, this was not the case (15).

Likewise, in this study, the influence of the state of the opposite jaw on the change in bone height was also not proven. In contrast to this, in the study conducted by Dorj et al. (2021), it was found that a statistically significant difference in bone change, depending on the antagonist, exists and is greater in the case of metal-ceramic as the antagonist (16).

When talking about the influence of gender and age on the amount of change in bone height, a statistically significant difference was not proven, regardless of the combination of prosthetic construction carriers. Research conducted by Negri et al. (2014) showed that the average change in men mostly increases in correlation with age, while this is not the case in women (15).

Kada je riječ o razlikama u prosječnoj resorpciji kosti na različitim mjestima, ovo je istraživanje u skladu s istraživanjem Hosnyja i suradnika (2000.) u kojemu je također zaključeno da nema razlike u promjeni visine kosti na mjestu implantata između zuba i implantata postavljenih na strukturama u usporedbi s implantatima nošenim na strukturama. U njihovu radu opisan je gubitak od 1 mm u prvoj polovici godine, nakon čega je slijedio godišnji pomak od 0,015 mm sljedećih 14 godina. Slični su zaključci i u studijama Gunnea i suradnka (1999.) i Lindha i suradnika (2001.) (8 –10).

Nije dokazana statistički značajna razlika u promjeni visine kosti ovisno o broju zuba nosača, za razliku od broja implantata koji se regresijskom analizom pokazao kao prediktorska varijabla sa statistički značajnim doprinosom promjeni visine kosti oko implantata u slučaju struktura postavljenih samo na implantatima. Tabrizi i suradnici nisu dokazali kao statistički značajan odnos između broja implantata i njegova utjecaja na gubitak koštane mase, što je suprotno gore navedenim rezultatima koji su dokazani regresijskom analizom (11).

Od studija koje se bave vezom endodontski liječenih zuba u vezi zub-implantat s obzirom na promjenu kosti, treba izdvojiti istraživanja Lindha i suradnika (2001.) i Blocka i suradnika (2002.). Lindh i suradnici nisu pokazali statistički značajan utjecaj endodontskog liječenja na promjenu visine kosti ni oko zuba, ni oko implantata koji su s njime vezani, kao što pokazuje i ovo istraživanje, a Block i suradnici su, s druge strane, dobili su oprečne rezultate na mjestu zuba nosača prethodno podvrgnutog endodonciji (10, 12).

Za utjecaj vrste implatološkog rada na količinu promjene visine kosti oko implantata, Malo i suradnici nisu dokazali statistički značajnu razliku (2011.), kao ni Babbush i suradnici (2011.) čiji zaključci također upućuju na to da se razlika u promjeni visine kosti nije pokazala statistički značajnom ovisno o tome je li riječ o klasičnom mostu ili konstrukciji all-on-4 (13, 14).

Dok u ovoj studiji nije dokazan statistički značajan utjecaj čeljusti u kojoj se nalazi konstrukcija na promjenu visine kosti, u studiji Negrija i suradnika (2014.) kod muškaraca s gornjom čeljusti kao nositeljicom rada promjena se povećava u korelaciji s dobi, a ako je nositeljica konstrukcije bila donja čeljust, to nije bio slučaj (15).

Nadalje, u ovoj studiji nije dokazan utjecaj stanja nasuprotne čeljusti na promjenu visine kosti. Suprotno tomu, u studiji koju su proveli Dorj i suradnici (2021) utvrđeno je da postoji statistički značajna razlika u koštanoj promjeni ovisno o antagonistu, a veća je u slučaju metal-keramike kao antagonista (16).

Kada je riječ o utjecaju spola i dobi na količinu promjene visine kosti, nije dokazana statistički značajna razlika, bez obzira na kombinaciju nosača protetičke konstrukcije. Negri i suradnici (2014.) u svojem su istraživanju pokazali da prosječna promjena kod muškaraca većinom raste u korelaciji s dobi, dok to nije slučaj kod žena (15).

Istraživanje koje su proveli Dorj i suradnici (2021.) pokazalo je statistički značajnu razliku u resorpciji kosti nakon 3 godine, pa bi se moglo zaključiti da vrijeme nošenja rada zapravo utječe na koštanu promjenu, što je u suprotnosti s ovim istraživanjem (16).

Research conducted by Dorj et al. (2021) showed a statistically significant difference in bone resorption in the period after 3 years, so one could conclude that duration of wearing a work affects bone change, which is in contrast to this research (16).

Norowski et al. (2009) examined the influence of the initial state, where it was proven that the ones with previous periodontal disease, who had a certain degree of resorption, also had 4-5 times higher prevalence of peri-implantitis and bone resorption than in patients without such anamnesis, which would, in contrast to the results of this research, indicate that the initial state of bone influences the further course of bone height change (17).

When speaking about the place where change happens in prosthetic works with a tooth- implant connection, although statistically insignificant, in this research, the changes occurred in the largest number of cases, as well as in the largest amount, at the place of the implant. This is supported by the research of Hoffman et al. (2012) where a statistically significant existence of a greater amount of bone change at the place of the implant in comparison to the tooth was observed (18).

There are a couple of limitations of this study that need to be mentioned. To begin with, it is a fact that this research was performed on a relatively small sample size, with a large dispersion of data (including different ages, sex, working time, initial condition, etc.). It is also important to emphasize that the study was not performed on the patients, but on their panoramic radiographs, which means that no information about systemic health, smoking habits, or oral health status was available, which also contributes to the dispersion of data. Since measurements from panoramic radiographs were used as input data, the quality of the same depends on the position of the patient while taking the photo, the skill of the technician who takes the photo, and the examiner who does the measurements. Finally, a panoramic radiograph is a 2D image, which also increases possible mistakes, because of superpositions, distortions, and other artifacts.

Conclusion:

After the implant placement, whether it is connected to a natural tooth or another implant, resorptive changes occur, in both the area of the implant and the tooth. No statistically significant difference in bone resorption was shown between tooth-implant-supported and implant- implant-supported restorations. Furthermore, a statistically significant difference in a bone loss was not proven around the implant area versus the tooth area in tooth-implant-supported restorations. Examination of the influence of various factors (sex, age of the patient, working time, number of teeth involved in the construction, endodontic treatment, type of implant construction, jaw where the construction is located, condition of the opposite jaw, as well as the initial bone condition) did not show a statistically significant effect on bone loss neither around the tooth, nor the implant. By regression analysis, the number of implants has shown to be the only variable with a statistically significant contribution to the amount of bone height change in prosthetic constructions supported exclu-

Norowski i suradnici (2009.) ispitivali su utjecaj inicijalnog stanja te su dokazali da su oni s prethodnom parodontnom bolešću, koji su imali određeni stupanj resorpcije, imali i 4 do 5 puta veću prevalenciju periimplantitisa i resorpcije kosti nego pacijenti bez takve anamneze, što bi, za razliku od rezultata ovog istraživanja, upućivalo na to da početno stanje kosti utječe na daljnji tijek promjene visine kosti (17).

Kada je riječ o mjestu nastanka promjene kod protetičkih radova sa spojem zuba i implantata, iako statistički beznačajne, u ovom istraživanju promjene su se u najvećem broju slučajeva dogodile na mjestu implantata. To je potkrijepljeno istraživanjem Hoffmana i suradnika (2012.) koji su uočili statistički značajno veću količinu koštane promjene na mjestu implantata u odnosu na zub (18).

Ova studija ima nekoliko ograničenja koja treba spomenuti. Za početak, ovo je istraživanje provedeno na razmjerno malom uzorku, s velikom disperzijom podataka (uključujući različitu dob, spol, radno vrijeme, početno stanje itd.). Također je važno istaknuti da nije provedeno na pacijentima, nego na njihovim radiološkim panoramskim snimkama, što znači da nisu bile dostupne informacije o sustavnom zdravlju, navikama pušenja ili pak o oralnome zdravstvenom stanju, što također pridonosi disperziji podataka. Budući da su kao ulazni podatci korištena mjerenja s radioloških panoramskih snimki, njihova kvaliteta ovisila je o položaju pacijenta pri snimanju, vještini tehničara koji snima i ispitivača koji obavlja mjerenja. Konačno, radiološka panoramska snimka je 2D slika, što također povećava mogućnost pogreške zbog superpozicija, distorzija i drugih mogućih artefakata.

Zaključak

Poslije ugradnje implantata, bilo da je vezan s prirodnim zubom ili drugim implantatom, događaju se resorptivne promjene, kako u području implantata tako i u području zuba. Nije utvrđena statistički značajna razlika u resorpciji kosti između restauracija postavljenih na zubima i implantatima i onih isključivo na implantatima. Nadalje, nije dokazana statistički značajna razlika u gubitku koštane mase oko područja implantata u odnosu prema području zuba u restauracijama nošenima kombinacijom zuba i implantata. Ispitivanje utjecaja različitih čimbenika (spol, dob pacijenta, vrijeme nošenja, broj zuba nosača, endodontsko liječenje, vrsta implantološkog rada, čeljust u kojoj se rad nalazi, stanje nasuprotne čeljusti, kao i početno stanje kosti) nije pokazalo statistički značajan učinak na gubitak koštane mase ni oko zuba, ni oko implantata. Regresijskom analizom pokazalo se da je broj implantata jedina varijabla sa statistički značajnim doprinosom količini promjene visine kosti kod protetičkih konstrukcija postavljenih isključivo na implantate. Rezultati ovog istraži-

sively by implants. The results of this research may be a good basis for further research on the same topic with a larger sample and smaller dispersion of data.

Conflict of interest

None declared

Author's contribution: **M. B.** - collection and analysis of orthopan, statistical processing of data, processing of the same results and their comparison with the results of other research on this topic; **I. B.** – work mentor; **R. B.** - the production of the prosthetic works themselves, on which the research was carried out and the orthopan analysis of the same

vanja mogu biti dobra osnova za daljnja istraživanja o istoj temi, ali na većem uzorku i s manjom disperzijom podataka.

Sukob interesa

Autori nisu bili u sukobu interesa.

Doprinos autora: **M. B.** – prikupljanje i analiza ortopana, statistička obrada podataka, obrada istih rezultata i njihova usporedba s rezultatima drugih istraživanja o toj temi; **I. B.** – mentor rada; **R. B.** - izrada protetičkih radova na kojima je obavljeno istraživanje i ortopan analiza

Sažetak

Ciljevi: Primarni cilj bio je usporediti promjenu visine kosti koja se pojavljuje na mjestu zuba i implantata kod protetičkih nadomjestaka postavljenih na zube i implantate u odnosu na promjenu visine kosti koja nastaje na mjestu implantata kod protetičkih nadomjestaka postavljenih isključivo na implantatima. Sekundarni cilj bio je ispitati utjecaj različitih čimbenika kao što su broj zuba nosača, endodontska obrada zuba, broj implantata, vrsta implantološkog rada, čeljusti u kojoj se rad nalazi, stanje nasuprotne čeljusti, zatim utjecaj spola, dobi i vremena nošenja, te ispitati je li početna razina kosti utjecala na daljnju promjenu same visine kosti. **Materijali i metode:** U istraživanju su korištene radiološke panoramske snimke ukupno 50 ispitanika, od čega su na 25 snimki bili protetički nadomjestci postavljeni na kombinaciju zuba i implantata, a na ostalih 25 protetički nadomjestci postavljeni isključivo na implantatima. Visine kosti, mjerene od caklinsko-cementnoga spoja/vrata implantata do najapikalnije točke kosti, uzete su s ukupno dvije radiološke panoramske snimke za svakog ispitanika. Prva je snimljena odmah poslije ugradnje implantata, a druga, ujedno i posljednja, pola godine do sedam godina nakon implantacije, ovisno o vremenu snimanja pacijenta. Dobivena razlika pokazivala je resorpciju kosti, formiranje kosti ili pak stanje bez promjene. Ispitan je i utjecaj različitih čimbenika kao što su spol, dob pacijenta, vrijeme nošenja, broj zuba nosača, endodontsko liječenje, broj implantata, vrsta implantološkog rada, čeljust u kojoj se rad nalazi, stanje nasuprotne čeljusti i početno stanje kosti. Tijekom statističke analize korištene su tablice frekvencija, osnovni statistički parametri, Mann-Whitneyjev U test, Kruskal-Wallisova ANOVA, Wilcoxonov test i regresijska analiza, a rezultati su prikazani tablično i u obliku Paretova dijagrama t-vrijednosti. **Rezultati:** Nema statistički značajne razlike u promjeni visine kosti, bilo da je riječ o mjestu implantata (-0,359±1,009 i medijan vrijednosti 0,000) i mjestu zuba (-0,428±0,746 i medijan vrijednosti -0,150) kod restauracija postavljenih na zub i implantat, odnosno na mjestu implantata u slučaju struktura postavljenih samo na implantatima (-0,059±0,200 i vrijednost medijana -0,120). Kada je riječ o utjecaju ostalih čimbenika, regresijskom analizom broj implantata pokazao se kao jedini čimbenik sa statistički značajnim utjecajem (β = 0,54; P = 0,019) na promjenu razine kosti, ali samo kada je riječ o protetičkim strukturama postavljenima isključivo na implantatima. **Zaključak:** Nije dokazana značajna razlika u promjeni visine kosti, ni na mjestu zuba, ni na mjestu implantata kod protetičkih nadomjestaka postavljenih na zubima i implantatima u usporedbi s promjenom visine kosti oko implantata kod protetičkih nadomjestaka postavljenih isključivo na implantatima. Među svim ispitanim čimbenicima broj implantata pokazao je statistički značajan doprinos u količini promjene visine kosti u protetičkim konstrukcijama postavljenim isključivo na implantatima.

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References

1. Bianchi A, Sanfilippo F. Osteoporosis: the effect on mandibular bone resorption and therapeutic possibilities by means of implant prostheses. Int J Periodontics Restorative Dent. 2002 Jun;22(3):231-9.
2. Knezović-Zlatarić D, Čelebić A, Lazić B. Resorptive Changes of Maxillary and Mandibular Bone Structures in Removable Denture Wearers. Acta Stomatol Croat. 2002 Jun;36(2):253-9.
3. Geštakovski D. Occlusional concepts in implant prosthodontics (Thesis). Zagreb, Croatia: School of Dental Medicine, University of Zagreb 2018. (In Croatian).
4. Balaji TM, Varadarajan S, Jagannathan R, Mahendra J, Fageeh HI, Fageeh HN, Mushtaq S, Baeshen HA, Bhandi S, Gupta AA, Raj AT, Reda R, Patil S, Testarelli L. Melatonin as a Topical/Systemic Formulation for the Management of Periodontitis: A Systematic Review. Materials (Basel). 2021 May 6;14(9):2417. doi: 10.3390/ma14092417.
5. Guarnieri R, Zanza A, D'Angelo M, Di Nardo D, Del Giudice A, Mazzoni A, Reda R, Testarelli L. Correlation between Peri-Implant Marginal Bone Loss Progression and Peri-Implant Sulcular
6. Vukšić J. Occlusal principles in implant prosthodontics (Thesis). Zagreb, Croatia: School of Dental Medicine, University of Zagreb 2019. (In Croatian).
7. Albrektsson T, Zarb G, Worthington P, Eriksson AR. The long-term efficacy of currently used dental implants: a review and proposed criteria of success. Int J Oral Maxillofac Implants. 1986;1(1):11-25.
8. Hosny M, Duyck J, van Steenberghe D, Naert I. Within-subject comparison between connected and nonconnected tooth-to-implant fixed partial prostheses: up to 14-year follow-up study. Int J Prosthodont. 2000 Jul-Aug;13(4):340-6.
9. Gunne J, Astrand P, Lindh T, Borg K, Olsson M. Tooth-implant and implant-supported fixed partial dentures: a 10-year report. Int J Prosthodont. 1999 May-Jun;12(3):216-21.
10. Lindh T, Dahlgren S, Gunnarsson K, Josefsson T, Nilson H, Wilhelmsson P, et al. Tooth-implant-supported fixed prostheses: a retrospective multicenter study. Int J Prosthodont. 2001 Jul-Aug;14(4):321-8.
11. Tabrizi R, Shaban Nejhad, Fayyazi A, Moslemi HR, Shafiei Sh. Does the Number of Dental Implants Affect Marginal Bone Loss in the Posterior Mandible? J Dent Shiraz Univ Med Sci., 2022 September; 23(2 Suppl): 383-386
12. Block MS, Lirette D, Gardiner D, Li L, Finger IM, Hochstedler J, et al. Prospective evaluation of implants connected to teeth. Int J Oral Maxillofac Implants. 2002 Jul-Aug;17(4):473-87.

13. Maló P, de Araújo Nobre M, Lopes A, Francischone C, Rigolizzo M. "All-on-4" immediate-function concept for completely edentulous maxillae: a clinical report on the medium (3 years) and long-term (5 years) outcomes. Clin Implant Dent Relat Res. 2012 May;14 Suppl 1:e139-50. doi: 10.1111/j.1708-8208.2011.00395.x.
14. Babbush CA, Kutsko GT, Brokloff J. The all-on-four immediate function treatment concept with NobelActive implants: a retrospective study. J Oral Implantol. 2011 Aug;37(4):431-45.
15. Negri M, Galli C, Smerieri A, Macaluso GM, Manfredi E, Ghiacci G, et al. The effect of age, gender, and insertion site on marginal bone loss around endosseous implants: results from a 3-year trial with premium implant system. Biomed Res Int. 2014;2014:369051. doi: 10.1155/2014/369051.
16. Dorj O, Lin HK, Salamanca E, Pan YH, Wu YF, Hsu YS, et al. Effect of Opposite Tooth Condition on Marginal Bone Loss around Submerged Dental Implants: A Retrospective Study with a 3-Year Follow-Up. Int J Environ Res Public Health. 2021 Oct 13;18(20):10715. doi: 10.3390/ijerph182010715.
17. Norowski PA Jr, Bumgardner JD. Biomaterial and antibiotic strategies for peri-implantitis: a review. J Biomed Mater Res B Appl Biomater. 2009 Feb;88(2):530-43.
18. Hoffmann O, Zafiropoulos GG. Tooth-implant connection: a review. J Oral Implantol. 2012 Apr;38(2):194-200.