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IZVORNI ZNANSTVENI RAD
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Razina buke u pedodontskoj stomatološkoj ordinaciji

Noise Levels in a Pedodontic Dental Practice

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Sažetak
Svrha rada bila je odrediti razinu buke u pedodontskoj stomatološkoj ordinaciji koja prije toga nije bila akustički obrađena te anketirati stomatologe kako bi se procijenila izvrgnutost neželjenim zvukovima stomatoloških uređaja tijekom redovitoga dnevnog radnog vremena. Mjerenje buke obavljeno je u Zavodu za pedodonciju Stomatološkog fakulteta Sveučilišta u Zagrebu u ordinaciji sa šest radnih mjesta, a koristili su se najčešće potrebni stomatološki nastavci (turbina s vodom, mikromotor s vodom i bez vode, puster i SONICflex). Odabrana su dva načina ispitivanja - tradicionalna, normirana metoda jednokanalnoga zvukomjera s modulom za spektralnu analizu te nova dvokanalna metoda pomoću umjetne glave. Ekvivalentna razina osnovne buke izmjerena s korekcijskim filtrom A (L_{Aeq}) iznosila je L_{Aeq} = 54,4 dB (decibela). Razina buke u lijevom uhu umjetne glave bila je 53 dB, a u desnom 55 dB. Buka koja se stvara tijekom rada turbine s vodom iznosila je L_{Aeq} = 81 dB, mikromotora s vodom L_{Aeq} = 75 dB, mikromotora bez vode L_{Aeq} = 72,5 dB, pustera L_{Aeq} = 81,5 dB i SONICflex L_{Aeq} = 76 dB. Ekvivalentna razina buke kojoj je izložen stomatolog bila je L_{Aeq} = 72,1 dB, što uz korekciju zbog tonalne buke iznosi L_{Aeq} = 77,1 dB. Na temelju dobivenih rezultata može se zaključiti da je buka - iako ekvivalentna razina buke ne premašuje L_{Aeq} = 90 dB, što bi bio razlog za urgentno djelovanje - ipak veća od L_{Aeq} = 70 dB, a to je gornja granica dopuštena prema odredbama Pravilnika o zaštiti na radu. Kako buci u ordinaciji nije izvrgnut samo terapeutski tim nego i pedodontski pacijent, trebalo bi akustički obraditi prostoriju u kojoj se obavlja djelatnost, kako bi se smanjile neželjene posljedice poput straha, stresa i uznemirenosti pacijenata.

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Ključne riječi
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Uvod

Buka djeluje kao stresni čimbenik, pa može imati auditorne i neauditorne posljedice, a reakcije osoba ovise o intenzitetu, frekvenciji, trajanju i složenosti zvuka. Strah od stomatološkog zahvata poznat je mnogim pacijentima - osobito ako su u dječjoj ili adolescentskoj dobi, a manifestira se mišićnom napetošću, ubrzanim disanjem, ubrzanim srčanim bilom, znojenjem, grčevima u trbuhu i promjenama tlaka (1). Najčešćim provocirajućim čimbenicima

Introduction

Noise is a stressor that might cause auditory and non-auditory effects, and a person's reaction to it depends on the intensity, frequency, duration and complexity of the sound. Fear of dental treatments is present in many patients, particularly in children and adolescents, and it is manifested in muscular tension, accelerated breathing rate, accelerated heartbeat, sweating, stomach pains and blood pressure changes (1). The most frequent factors provoking such conza takva stanja smatraju se buka i vibracije rotirajućih instrumenata, aplikacija anestezije, ali i sam dolazak u stomatološku ordinaciju. Prema istraživanju Willershausena i suradnika (1), na ljestvici čimbenika koji potiču strah na prvom su mjestu upravo buka i vibracije rotirajućih instrumenata tijekom zahvata. Stomatološki tretman još se najčešće obavlja klasičnim rotirajućim instrumentima, no nove metode, poput ozonske terapije te aplikacije različitih vrsta lasera, donose nove prednosti, osobito kod djece kojoj je potrebna dugotrajnija psihološka priprema i potpuno bezbolan zahvat. Osim kliničkih, prednosti takvih novih metoda sadržavaju i važne elemente za prevladavanje straha od stomatološkog zahvata, poput isključivanja lokalne anestezije kao nepotrebne i rada bez buke i vibracija tijekom samog zahvata (2-5). Kako se te nove terapijske metode još ne primjenjuju masovno, valja tijekom rada i na druge načine kontrolirati buku. No, da bi se to moglo učiniti nužno je odrediti njezinu razinu u radnom prostoru. Iz literature se zna da buka ne utječe negativno samo na pacijenta, nego i na terapeuta koji je svaki dan dugo izvrgnut njezinu štetnom djelovanju (6-11). Dosadašnje metode uglavnom su bile standardne, pa je svrha ovoga rada odrediti razinu buke tijekom rada u pedodontskoj stomatološkoj ordinaciji i to tradicionalnom, normiranom metodom mjerenja - jednokanalnim zvukomjerom s modulom za spektralnu analizu, ali i novom dvokanalnom metodom pomoću umjetne glave. Za razliku od uobičajenoga jednokanalnog mjerenja, u ovom radu - zbog primjene dvokanalne metode - očekujemo subjektivniju procjenu djelovanja buke na čovjeka (12, 13). Dvokanalna metoda sa svojom spektralnom kompozicijom može registriratirazinu buke, smjer dolaska buke i različitost njezinog intenziteta u pojedinom uhu. Stoga su ciljevi ovog istraživanja: 1. odrediti razinu buke tijekom rada u pedodontskoj ordinaciji pomoću klasične jednokanalne metode mjerenja razine zvuka, 2. odrediti utjecaj buke na stomatologa tijekom dnevnog radnog vremena, 3. odrediti potrebu za akustičkom obradom prostora.

Materijal i metode

Opis objekta mjerenja i prostorije

Objekt mjerenja bila je buka tijekom rada u stomatološkoj ordinaciji Zavoda za pedodonciju Stomatološkog fakulteta Sveučilišta u Zagrebu. Potencijalni izvori buke na samom stomatološkom uređaju zvukovi su koje proizvodi rad s pojedinim nastavcima (u našem slučaju turbina T1 Siemens, mikromotor T1 Siemens s vodom i bez vode, puster

ditions are the noise and vibrations made by rotating instruments, application of anaesthesia, but also the very coming to a dental practice. According to the research made by Willershausen B et al. (1), on the scale of factors causing fear the highest place is taken by the noise and vibrations during a dental treatment with rotating instruments. Most commonly dental treatments are still conducted with classical rotating instruments. However, the introduction of new methods such as ozone therapy, or application of various types of lasers, offers additional advantages, especially in children, who need a longer psychological preparation and a completely painless treatment. Apart from clinical advantages, such new methods contain also important elements for the reduction of fear from dental treatments, such as exclusion of local anaesthesia from the treatment as unnecessary and the lack of noise and vibrations during the treatment (2-5). Since such new therapeutic methods are still not widely applied, it is necessary to use other methods to control the noise during the dentist's work. In order to be able to control the noise, one should first determine its level in the work environment. The available literature shows that noise has an adverse impact not only on the patient but also on the therapist, who is exposed to its harmful effect for several hours on a daily basis (6-11). The methods of noise level measurement applied so far have mostly been standard. There is a new dual-chanel method which is expected to provide better assessment of the impact of noise on people (12, 13). Dual-channel method with its spectral composition can register the noise level, the direction of noise and differences in its intensity in an ear. Therefore, the aims of the present research are: 1. to determine the level of noise during work in a pediatric practice by traditional single-channel sound level meter (SLM), 2. to assess the impact of the dentist caused by such noise during daily work, 3. to assess the need for acoustic treatment of the room.

Materials and Methods

Description of the Object of Measurement and of the Room

The object of measurement was the noise made during work in a dental practice at the Department of Pedodontics, School of Dental Medicine, University of Zagreb. The potential sources of noise on the dental equipment are the sounds made during work with certain handpieces (in our case the turbine T1 Siemens, micromotor T1 Siemens with water and with-i SONICflex KaVo). Mjerio se isključivo pojedinačni izvor na jednom stolcu. Razina buke pojedinog nastavka mjerila se dok je nastavak radio s maksimalnim brojem okretaja na ekstrahiranom zubu iz ortodontskih razloga. U samoj ordinaciji bilo je šest stolaca te se u tom slučaju, ako je vremenska raspodjela rada po pojedinačnom stolcu slučajna, stvara kontinuirana zvučna kulisa znatne jačine i slučajne vremenske raspodjele buke. Ukratko, to znači kako se može dogoditi da u tijeku cijeloga radnog dana ne bude ni minute tišine i da u svakom trenutku buka može dobiti bilo koju vrijednost između osnovne razine (razina buke što ju stvaraju uređaji koji nisu vezani za sam terapijski postupak s pacijentom, kao i ona što dopire izvana u ordinaciju) i najveće buke (istodobni rad na svim radnim mjestima). Prostorija u kojoj se mjerilo bila je ordinacija sa šest radnih mjesta, tlocrtnih dimenzija približno 7 x 8 m i visine 3,2 m. Prostorija nije bila akustički obrađena te je davala dojam poluodječnosti.

Popis uporabljene instrumentacije

Instrumentacija za mjerenje, snimanje i analizu signala sastojala se od: umjetne glave tvrtke "Neumann", preciznoga modularnog digitalnog zvukomjera Bruel&Kjaer model 2231, prijenosnog digitalnog kasetofona AIWA, aktivnoga monitorskog zvučnika Nagra DSM, generatora bijelog i ružičastog šuma, monitorskih slušalica AKG K-141 i analizatora signala Hewlett-Packard 35665 A.

Metoda mjerenja

Koristile su se dvije metode. Radi usporedbe s dopuštenim vrijednostima propisanima Pravilnikom o općim mjerama i normativima zaštite na radu od buke u radnim prostorijama, prva je potpuno odgovarala metodi određenoj tim dokumentom. To je mjerenje bilo jednokanalno i obavljeno je zvukomjerom s neusmjerenim mikrofonom na udaljenosti 0,2 m od uha osobe koja na tome mjestu radi. Mjerila se ekvivalentna razina buke, tj. dobivena vrijednost odgovarala je srednjoj vrijednosti buke za pojedini nastavak. Korištenjem korekcijskog filtra s "A" karakteristikom (odgovara frekvencijskoj karakteristici ljudskog uha) dobila se ukupna razina buke za sve frekvencije. Budući da je za ovaj rad bilo zanimljivo ustanoviti i spektralni sastav buke,

out water, air syringe and SONICflex KaVo). The object of measurement was only the noise coming from a single source, i.e. from one dental chair. The level of noise coming from a single dental handpiece was measured while the handpiece was being used with the maximum number of revolutions, on, for orthodontic purposes, an extracted tooth. In the dental practice there were six dental chairs. Under such circumstances, taking into account that the distribution of working time is purely random, a continual background noise of considerable volume and random distribution in time is created. This means that there is a high degree of probability that during a workday there will not be a single minute of silence but that at any moment the noise created there can have any value between the level of background noise (level of noise made by the equipment not directly linked to the therapeutic procedure applied on the patient, and the noise from outside of the dental practice) and the maximum noise (simultaneous work on all dental chairs). The room where the measurement was conducted was a dental practice (with six workplaces), with approximate dimensions 7 x 8 m, 3.2. m high. The room was not acoustically equipped and gave the impression of semi-echoic.

Applied Instruments

The instruments for measurement, recording and analysis of signals consisted of an artificial head produced by "Neumann", a precise modular digital SLM Bruel&Kjaer – model 2231, a portable digital cassette recorder AIWA, an active monitor loudspeaker Nagra DSM, a generator of white and pink noise, a monitor headset AKG K-141, and a signal analyser Hewlett-Packard 35665 A.

Method of Measurement

Two methods of measurement were applied. For the purpose of comparison with the permitted values as set in the Regulation on General Measures and Standards of Noise Protection at Workplaces, the first method completely corresponded to the method prescribed in the above Regulation. This single-channel measurement is conducted by a SLM with an omnidirectional microphone at a distance of 0.2 m from the ear of a dentist. The equivalent level of noise was measured, i.e. the obtained value corresponded to the mean value of noise for a certain handpiece. With the application of a correction filter with an "A" characteristic (which corresponds to the frequency characteristic of a human ear), the overall level of noise for all frequencies was expressed. As it was interesting for this paper mjerile su se istodobno i njezine razine u svakoj oktavi od 31,5 Hz do 8 kHz. Tijekom tih mjerenja nije se rabio korekcijski filtar, nego je zvukomjer bio u frekvencijski linearnom načinu rada. Druga metoda novost je u mjerenjima buke, jer je riječ o mjerenju pomoću umjetne glave. To je dvokanalno mjerenje, što znači da se u svakom uhu umjetne glave nalazi jedan mikrofon. Uređaj se postavlja u položaj osobe koja radi, u ovom slučaju liječnice. I za tu metodu koristio se korekcijski filtar, no on je u ovom slučaju rezultat dimenzija glave, ušnih školjki i zvukovoda kojim zvuk dolazi do membrana ugrađenih mjernih mikrofona s linearnim frekvencijskim karakteristikama. Već iz ovog opisa jasno je da umjetna glava vrlo vjerno dovodi zvuk do mikrofona, točno onako kako on doista stiže do bubnjića ljudskog uha. Dodatna prednost, kako bi se postigao stvarni osjećaj jačine zvuka, jest usmjerenost umjetne glave, što ovisi o razmaku ušiju i obliku ušnih školjki. Ako usporedimo opisane metode mjerenja, tada za prvu možemo reći da je objektivna, a cilj joj je izmjeriti razinu zvučnog tlaka na mjestu na kojemu se nalazi mikrofon zvukomjera. Zbog neusmjerenog mikrofona svi smjerovi dolaska zvuka jednako su važni. Svrha dvokanalnog mjerenja, uz korištenje umjetne glave, jest subjektivizirati utjecaj buke na mjestu osobe koja joj je izložena. Umjetna glava kao receptor zvuka prostorno je usmjerena, tj. postoje smjerovi iz kojih će zvuk biti bolje primljen negoli iz drugih. Ta usmjerenost nije jednaka za sve frekvencije i općenito se može reći da je njezin utjecaj veći na višim frekvencijama. Zbog toga je ta metoda perspektivna u mjerenju buke kako bi se dobio rezultat subjektivnog djelovanja buke na čovjeka, pri čemu se uzima u obzir njezina razina, spektralni sastav, smjer dolaska i razlika intenziteta na pojedinom uhu.

Osim navedenih metoda mjerenja buke, u istraživanje je bilo uključeno i deset stomatologa – oni su ispunili anketni upitnik u kojemu su sami tijekom dana određivali vrijeme korištenja pojedinog nastavka.

to determine also the spectral composition of such noise, the levels of noise in each octave band from 31.5 Hz to 8 kHz were measured simultaneously. In those measurements no correction filter was applied, but the SLM was in a linear frequency mode. This method presents a novelty in noise measurements because the measurement is conducted by means of an artificial head. It is a dual-channel measurement procedure, which means that there is a microphone in each of the artificial head's ears. The artificial head is kept in the position of the dentist working on that dental chair. This method applies also a correction filter, but in this case it was merely a product of the dimensions of the head, pinae and ear canals by which the sound reaches the membranes of the installed measuring microphones. The above description shows that an artificial head brings the sound to the microphone with a high fidelity, as it in reality reaches the tympanic membrane of the human ear. An additional advantage which helps to achieve the real sensation of the volume of sound is orientation of the artificial head, a consequence of the distance between the ears and the form of pinae. If the above described methods of measurement are compared, the first can be described as an objective method aiming at measurement of the sound pressure level on the point of the SLM microphone. Because of an omnidirectional microphone, all directions from which the sound comes are equally important. However, the objective of dual-channel measurement with the application of the artificial head is to present the impact of noise subjectively in respect of the person exposed to that noise. The artificial head as a sound receptor is spatially oriented, i.e. there are certain directions from which the sound will be received better. This orientation is not the same for all frequencies and generally the impact is more visible on higher frequencies. Therefore this method represents the future of noise measurement for the purpose of presenting the subjective impact of noise on humans, taking into account the noise level, its spectral composition, the direction of noise and differences in intensity in a certain ear.

Apart from the above described methods of noise measurement, the research also involved ten dentists who filled in the questionnaire in which they were asked to determine the duration of use of certain dental handpieces in a day.

Rezultati

Zahvaljujući objema opisanima metodama mjerenja buke dokazani su neželjeni zvukovi tijekom rada u stomatološkoj ordinaciji. U Tablici 1. predstavljena su mjerenja jednokanalnom metodom i uočljive su ekvivalentne razine buke (L_{Aeq} u dB) te oktavne razine (frekvencije od 31,5 Hz do 8 kHz) za svaki nastavak. Osim razina buke, u Tablicu 1. upisano je i prosječno vrijeme rada sa svakim nastavkom. Iz ankete je jasno da se najduže tijekom stomatološkog zahvata radi s mikromotorom bez vode, zatim turbinom s vodom, pa tek nakon toga s ostalim navedenim uređajima. Osnovna buka iznosila je L_{Aeq} = 54,4 dB. Turbina s vodom i puster proizvode najvišu razinu buke (81 i 81,5 dB), a mikromotor s vodom i bez vode te SONICflex proizvode manju buku (u rasponu od 72,5 do 76 dB). Kontinuirani rast razine buke prema višim frekvencijama proizvode SONICflex i mikromotor s vodom i bez vode te se u njihovoj buci mogu očekivati ultrazvučne komponente. Tablica 2. daje prikaz razine buke izmjerene dvokanalnom metodom pomoću umjetne

Results

By means of both above presented methods of noise measurement, the presence of undesired sounds in a dental practice has been proved. Table 1 presents the results obtained in noise measurement by means of SLM. One can see the equivalent levels of noise (L_{Aeq} u dB), as well as octave band noise levels (frequencies from 31.5 Hz to 8 kHz) for each handpiece. Apart from the noise levels, Table 1 also includes an average time spent on work with each of the handpieces. The questionnaire shows that for most of the time during a dental treatment the micromotor without water is used, followed by the turbine with water and all other earlier mentioned handpieces. The background noise was L_{Aeq} = 54.4 dB. The turbine with water, together with the air syringe, produces the highest level of noise (81 and 81.5 dB), while the micromotor both with or without water and SONICflex produces lower levels of noise (in the range from 72.5 to 76 dB). A continual increase of the noise level toward higher frequencies is made by SONICflex and the micromo-

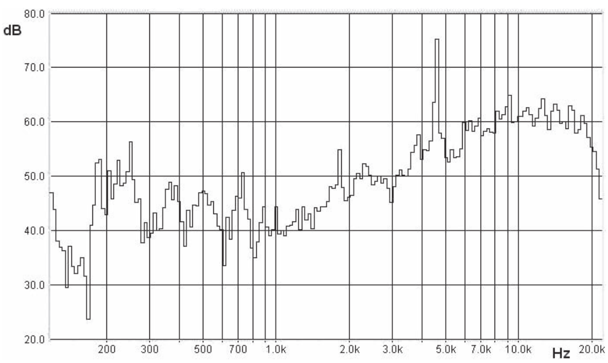
Tablica 1. Ekvivalentna razina buke (L_{Aeq} u dB) i prosječna uporaba nastavaka u minutama tijekom dana (min/dan) i razina buke prikazana po oktavnim pojasevima (frekvencija (Hz))
Table 1. Noise levels (L_{Aeq} in dB) and approximate usage of particular tool in minutes per day (min/day) and noise levels in standard octave bands (Frequency in Hz)

Izvor buke • Noise source	L_{Aeq} dB	min/dan • min/day	Frekvencija (Hz) • Frequency (Hz)								
			31,5	63	125	250	500	1k	2k	4k	8k
Turbina s vodom • High speed handpiece (air turbine)	81	78	58	58	53	55	64	62	59	78	77
Mikromotor s vodom • Low speed handpiece (with water)	75	8	53	57	65	57	56	60	62	67	73
Mikromotor bez vode • Low speed handpiece (without water)	72,5	110	58	59	53	58	59	54	58	58	72
Puster • Air syringe	81,5	15	59	68	60	70	62	62	71	75	78
SONICflex	76	38	54	49	57	53	55	52	59	63	77
Osnovna buka • Background noise	61	208									

Tablica 2. Ekvivalentna razina buke (L_{Aeq} u dB) izmjerena umjetnom glavom na oba uha i zvukomjerom na mjestu lijevog uha
Table 2. Noise levels (L_{Aeq} in dB) measured by the artificial head on both ears and sound level meter on the left ear position

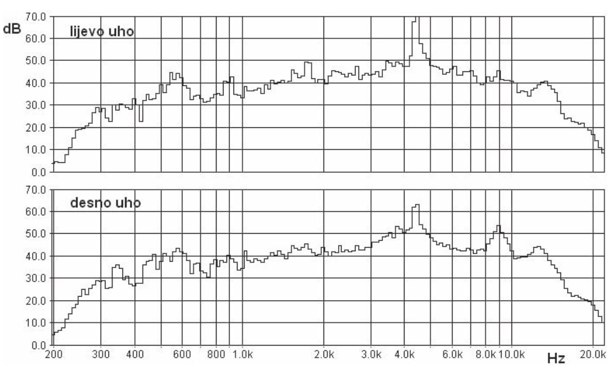
Izvor buke • Noise source	L_{Aeq} (dB)		
	Umjetna glava • Artificial head		Zvukomjer • Sound level meter
	Lijevo uho • Left ear	Desno uho • Right ear	
Turbina s vodom • High speed handpiece (air turbine)	73,6	69,5	81,0
Mikromotor s vodom • Low speed handpiece (with water)	72,6	69,0	75,0
Mikromotor bez vode • Low speed handpiece (without water)	70,7	61,5	72,5
Puster • Air syringe	73,0	70,8	81,5
SONICflex	71,9	66,3	76,0
Osnovna buka • Background noise	53,0	55,0	54,4

glave, s mjerenjima zvukomjerom na poziciji uha bližeg izvoru buke. Više razine buke izmjerene su u lijevom uhu, jer je bilo bliže njezinu izvoru. Budući da dvokanalna metoda nema linearnu karakteristiku, slijede slike vezane za analizu jednokanalnog mjerenja. Spektralna analiza buke na Slici 1. pokazuje da se radi o izdvojenim tonovima, što subjektivno predstavlja dodatnu neugodu. Ako se izmjeri razina buke i prosječno vrijeme rada s pojedinim nastavkom, dobiva se računska vrijednost ekvivalentne razine buke (L_{Aeq}) za 8-satno radno vrijeme od L_{Aeq} = 72,1 dB. Uzmu li se u obzir izražene tonalne komponente u buci, tu vrijednost treba prema valjanim zakonskim aktima povećati za 5 dB, pa tako dobivamo da je L_{Aeq} = 77,1 dB. Zakonom dopuštena vrijednost buke tijekom rada u stomatološkoj ordinaciji iznosi L_{Aeq} = 70 dB, što je u našem slučaju premašeno za 7 dB te bi trebalo provesti mjere kako bi se ona smanjila. Oktavne razine buke svih nastavaka mjerene zvukomjerom, predstavljene su grafički na Slici 2. Ako analiziramo dobivene po-



Slika 1. Spektar buke turbine dobiven jednokanalnom metodom

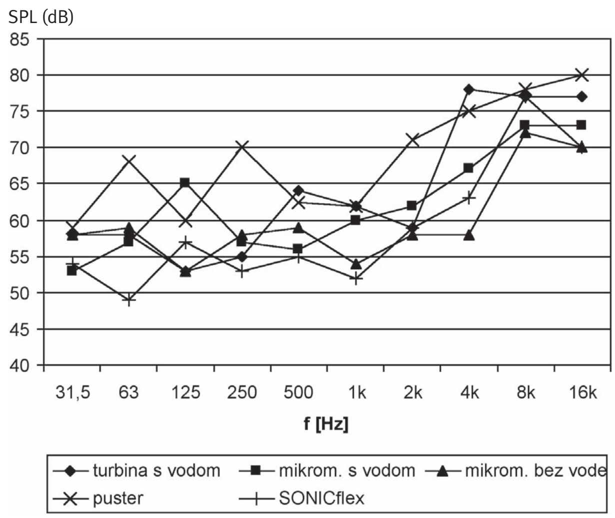
Figure 1. Noise spectrum of high speed handpiece (air turbine) obtained by single-channel method



Slika 3. Spektri buke turbine dobiveni dvokanalnom metodom

Figure 3. Noise spectra of high speed handpiece (air turbine) obtained by dual-channel method

tor both with and without water. Moreover, one can also expect the presence of ultrasound components in their noise. Table 2 presents the noise level measured by a dual-channel method, by means of an artificial head, compared with measurements conducted by a SLM on the position of the ear closer to the source of noise. Higher levels of noise were measured in the left ear which was closer to the source of noise. Since the dual-channel method has no linear characteristic, presented images are related to an SLM measurement. The spectral analysis of noise in Fig. 1 shows that it was the noise with separate tones which subjectively represents additional unpleasantness. Using the measured noise levels and the average duration of work with a certain handpiece, a computational value of the equivalent level of noise (L_{Aeq}) for eight working hours is obtained



Slika 2. Razine buke (SPL u dB) svih nastavaka prema frekvencijama (f u Hz)

Figure 2. Noise levels (sound pressure level (SPL) in dB) vs. frequency (f in Hz)

and amounts to L_{Aeq} = 72,1 dB. Taking into account the existence of expressed tonal components in such noise, pursuant to the applicable regulations this value should be increased by 5 dB, which gives L_{Aeq} = 77,1 dB. The legally permitted noise level in a dental practice is L_{Aeq} = 70 dB, which in our case has been exceeded by 7 dB. The octave band noise levels made by all the handpieces and measured by a SLM were graphically presented in Fig. 2. One can see from Fig. 2 that most of the sound power is found on higher frequencies and that harmonic components of high levels could be expected also in the ultrasound section. The spectrum of noise obtained by means of an artificial head (Fig. 3) shows datke jasno je da se glavnina zvučne snage nalazi na višim frekvencijama i da se harmonične komponente visokih razina mogu očekivati i u ultrazvučnom području. Spektar buke dobiven pomoću umjetne glave (Slika 3.) pokazuje da zbog konfiguracije vanjskog uha slabi spektar buke u području visokih frekvencija te da treba dodatno provjeriti stvarni utjecaj ultrazvučnih komponenti.

Rasprava

Prema podacima iz našeg istraživanja buka koja nastaje tijekom rada u stomatološkoj ordinaciji ne prelazi 85 dB, pa nema potrebe za hitnu primjenu mjera za zaštitu od buke na radnom mjestu. Slične rezultate, a oni također ne prelaze navedenu granicu, dobili su i drugi autori koji se bave istim područjem kao i mi u našem prvom pokusnom istraživanju (11, 14-16). Kako je dopuštena buka koja potječe od uređaja na radnom mjestu na kojemu se obavlja rad definicijom najbliži stomatološkom radu 70 dB, naši rezultati pokazuju da ju je potrebno smanjiti. U pedodontskoj stomatološkoj ordinaciji dva su razloga zbog kojih je potrebna kontrola buke. Prvi je utjecaj na pacijenta kod kojega buka izaziva strah i odbojnost prema tretmanu, a kod terapeuta su moguće neželjene fiziološke smetnje (najčešće sluha) (1, 6, 12). Jednokanalno mjerenje buke standardna je metoda i često se primjenjuje u praksi, pa se i dobiveni rezultati (Tablica 1.) jednostavno mogu usporediti s rezultatima drugih autora (13-15, 17). Najbučniji nastavci bili su puster i turbina s 81 do 81,5 dB, za razliku od Setcosa i suradnika (15) koji su dobili najveću vrijednost za ultrazvučni skidač kamenca (88 dB - naš SONICflex iznosi 76 dB), a mikromotor je u sličnim vrijednostima s našim (od 72,5 do 75 dB). Sorainen i suradnici (14, 17) dobili su za mikromotor razinu buke od 76 i 77 dB, a za turbinu raspon od 77 do 82 dB, u što se uklapaju i naše vrijednosti. Glavnina zvučne snage buke nastavaka nalazi se na višim frekvencijama, što upozorava na to da mogu postojati i ultrazvučne komponente (Slika 2.) koje valja još istražiti. Apsolutne vrijednosti dobivene dvokanalnom metodom pomoću umjetne glave bile su manje od vrijednosti jednokanalne metode (Tablica 2.). U literaturi se ne opisuje dvokanalna metoda, pa dobivene rezultate ne možemo uspoređivati, no uspoređivali smo ih s jednokanalnom metodom. Jednokanalna metoda koristi se frekvencijskom kompenzacijom (filtar A) kako bi se rezultat subjektivizirao. Dvokanalna metoda uspješnije subjektivizira rezultat, jer uvodi i prostornu korekciju kojom se uzima u obzir usmjerenost ljudskog

that, due to the configuration of the external ear, a decrease of the noise spectrum occurs in the high frequency section. The real impact of ultrasound components should be additionally checked.

Discussion

The noise made during work at a dental practice, according to our research, does not exceed 85 dB. Therefore there is no need for any urgent application of noise protection measures at workplaces. Comparable results that do not exceed the above mentioned limit were also obtained by other authors in the same field (11, 14-16). Since the permitted noise made by the equipment at a workplace, at which some work, most closely matching the dentist's work, is set at 70 dB, our results indicate the necessity to reduce the noise. There are two reasons for the control of noise in a pedodontic practice. The first one is the impact on the patient in whom such noise causes fear and anxiety, and the second one is the dentist, who is exposed to the noise from which undesirable physiological disorders are possible (mostly hearing impediments) (1, 6, 12). Single-channel noise measurement is a standard method, widely applied in electroacoustics, and therefore these results (Table 1) are simply comparable to the results obtained by other authors (13-15, 17). The noisiest handpieces were the air syringe and the turbine with the noise level of 81-81.5 dB, in contrast to the research conducted by Setcos et al. (15), who obtained the highest value for the ultrasound scaler (88 dB) (our SONICflex measured 76 dB). Their handpiece showed similar values as ours (72.5-75 dB). Sorainen et al. (14, 17) obtained the noise level of 76 and 77 dB for the micromotor, and a range of 77 to 82 dB for the turbine, which corresponds to our values. Most of the sound power of the noise made by dental handpieces is found in higher frequencies, which points to possible existence of ultrasound components of noise (Fig. 2), requiring additional research. Absolute values obtained by the dual-channel method by means of an artificial head were lower than those obtained by the single-channel method (Table 2). As there is no application of the dual-channel method described in available literature, the obtained results cannot be compared. Our comparison with the single-channel method, however, will be discussed.

uha, ali i izvora zvuka. Zato su i dobivene vrijednosti niže, a istodobno i bliže stvarnim vrijednostima zvučnog tlaka na samom bubnjiću. Manifestacija prostorne usmjerenosti očituje se u višim razinama na uhu bliže izvoru buke. Razliku između jednokanalne i dvokanalne metode mjerenja buke pokazali smo i spektralnom analizom (Slika 1., Slika 3.). Slabljenje viših frekvencija buke u dvokanalnoj metodi rezultat je fiziološkog prigušivanja u zvukovodu, što jednokanalna metoda može korigirati isključivo na umjetan način filtrom A. Izdizanje dominantne frekvencije buke u odnosu prema ostalom dijelu spektra, rezultat je položaja izvora buke u smjeru najveće osjetljivosti uha, što jednokanalna metoda uopće ne može korigirati. Sam dvokanalni način mjerenja omogućuje nam realnije rezultate, jer se koristi uhom kao receptorom buke, no iako su te vrijednosti manje nego pri jednokanalnom načinu mjerenja, ipak sve prelaze 70 dB te bi bilo uputno primijeniti mjere kontrole buke u prostoriji. Canbek i suradnici (18) u svojim su istraživanjima dokazali da je maskiranje buke, kao jedan od načina njezine kontrole u prostoriji, djelotvorno u smanjenju stresa pacijenata.

Zaključak

Na temelju provedenog istraživanja može se zaključiti da - bez obzira na metodu kojom se mjeri buka - u ispitivanoj stomatološkoj ordinaciji postoji buka koja prema Zakonu o zaštiti na radu prelazi dopuštenih 70 dB (A). Buka koju proizvode nastavci ima nepromjenjiv sastav s izraženim tonalnim komponentama, što ju čini neugodnijom za okolinu nego što bi bilo promatrajući samu njezinu razinu. Raspon buke tijekom jednokanalnoga načina mjerenja bio je viši u odnosu prema dvokanalnom mjerenju, koje pak za razliku od jednokanalnoga ima različitu percepciju visokih frekvencija za oba uha i daje dvije različite brojčane vrijednosti, ovisno o blizini izvora buke. Tradicionalne objektivne metode analize i mjerenja nisu dovoljne za analizu proizvedenog zvuka. Zapravo, jedino ljudsko uho (njega simulira dvokanalna metoda mjerenja)

The single-channel method uses frequency compensation (filter A) for subjectivisation of the result. The dual-channel method is more efficient in subjectivisation of the result because it introduces spatial correction, which takes into account both the orientation of the ear and of the source of the sound. Therefore, the values thus obtained are lower but closer to real values of sound pressure on the tympanic membrane. Spatial orientation is manifested in higher values on the ear closer to the source of noise. A difference in two methods was also shown in spectral analysis (Fig. 1, Fig. 3). A decrease in higher frequencies of the noise measured by the dual-channel method is the result of suppression in the ear canal. On the contrary, the single-channel method can correct frequencies exclusively in an artificial way, by means of filter A. The prominence of the dominant frequency of noise in comparison to the rest of the spectrum is a consequence of the position of the source of noise in the direction of the highest sensitivity of the ear, and it could not have been corrected by the single-channel method. The dual-channel method of measurement provided more realistic results as it uses the ear as a noise receptor, although the values obtained by the dual-channel method were lower than those obtained by the single-channel method of measurement, all of them still exceeded 70 dB. Therefore it would be advisable to introduce some noise control measures at the dental practice. Canbek et al. (18) have shown that noise masking, as one of the methods of noise control in a room, proves to be efficient in reduction of the patients' stress and anxiety.

Conclusion

On the basis of the research conducted, it can be concluded that, regardless of the method of noise measurement, in the examined dental practice there is a noise level which exceeds the level of 70 dB(A) as permitted by the Safety at Work Regulations. The noise made by the handpieces expressed tonal components, which make it even more unpleasant for the environment than observed as the noise level itself. The noise range established by a SLM measurement was higher than the one obtained by dual-channel measurement. So, it showed a different perception of high frequencies for both ears and gave two different numerical values, differing in relation to the proximity to the source of noise. Traditional objective measuring and analysis methods are not enough to analyse produced sound. Finally, only the human ear can tell what kind of noise is more može odrediti koja je vrsta buke prihvatljivija. Kako je buka jedan od znatnih čimbenika straha djece od stomatološkog zahvata, bilo bi najbolje akustički obraditi prostoriju ili prikriti buku zvukovima specifičnih frekvencija i amplituda, čime bi se istodobno smanjila i izloženost stomatološkog tima već dobro poznatim neželjenim posljedicama buke.

acceptable. As noise is one of the important factors of fear from dental treatments in children, it would be advisable to treat acoustically the dental practice or to apply masking noise with specific frequencies and amplitudes, which would also reduce the dentists' exposure to the already well known and undesired consequences of noise.

Abstract
The aim of this paper was to measure the level of noise in the pedodontic practice, which hasn't been acoustically treated, and to interview the dentists in order to determine their exposure to undesired noise of dental equipment during daily work. The measurement of noise was conducted at the Department of Pedodontics, School of Dental Medicine, Zagreb, using the most frequently used handpieces (turbine, micromotor with and without water, air syringe and SONICflex). A standardised method of noise measurement was applied, by means of a single-channel sound level meter; and a new dual-channel method, by means of an artificial head. The equivalent level of background noise with a correction filter A (L_{Aeq}) was L_{Aeq} = 54.4 dB (decibel). The noise level in the left ear of the artificial head was 53 dB and in the right ear 55 dB. The noise made by a turbine was L_{Aeq} = 81 dB, by the micromotor with water L_{Aeq} = 75 dB, by the micromotor without water L_{Aeq} = 72.5 dB, by the air syringe L_{Aeq} = 81.5 dB and by SONICflex L_{Aeq} = 76 dB. The level of noise the dentist was exposed to was L_{Aeq} = 72.1 dB. It can be concluded that the equivalent level was above L_{Aeq} = 70 dB, which is the limit prescribed by the Safety at Work Regulations. Since it is not only the therapist that is exposed to noise, but also the pedodontic patient, it would be advisable to treat the room acoustically in order to reduce undesired consequences of the noise, such as the patient's fear, stress and anxiety.

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