ISSN: 0011-4553

Journal of Stomatology

Volume No. 78
Issue No. 3
September - December 2025

ENRICHED PUBLICATIONS PVT.LTD

JE - 18,Gupta Colony, Khirki Extn,
Malviya Nagar, New Delhi - 110017.
E- Mail: info@enrichedpublication.com
Phone :- +91-8877340707

ISSN: 0011-4553

Journal of Stomatology

Journal of Stomatology is a scientific quarterly published by the Polish Dental Association. It contains reviewed papers by both Polish and foreign authors within the field of all dental specialties, the medical ones, as well as those related to affiliated branches of science.

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ISSN: 0011-4553

Journal of Stomatology

(Volume No. 78, Issue No. 3, September - December 2025)

Contents

ISSN: 0011-4553

In vitro evaluation of the antibacterial effect of various root canal sealers on selected anaerobic bacteria*

Ocena przeciwbakteryjnego działania różnych uszczelniaczy kanałowych na wybrane szczepy bakterii beztlenowych – badania w warunkach in vitro*

Małgorzata Pawińska1, Grzegorz Szczurko1, Anna Kierklo2, Elżbieta Łuczaj-Cepowicz3, Grażyna Marczuk-Kolada3, Katarzyna Leszczyńska4

A B S T R A C T

Aim of the study. To determine and compare the antibacterial activity of various root canal sealers against selected strains of anaerobic bacteria: Fusobacterium nucleatum ATCC Peptostreptococcus anaerobius ATCC 27337.**Material and Methods.** The materials tested in this study included AH Plus Jet (AH), Apexit Plus (AP), Endomethasone N (EN), Epiphany (EP), GuttaFlow (GF), Roeko Seal Automix (RSA), Sealapex (SP) and Tubliseal (TS). The antibacterial effect of the freshly mixed sealers on the above mentioned strains of bacteria was evaluated with the use of the agar diffusion test. After inoculation with the bacteria and applying the materials, the agar plates were incubated at 37°C for one week in an atmosphere of 5-10% CO2. The results were obtainedStreszczenie**Cel pracy.** Ocena i porównanie antybakteryjnej aktywności różnych uszczelniaczy kanałowych względem wybranych szczepów bakterii beztlenowych: Fusobacterium nucleatum ATCC 25586, Porphyromonas gingivalis ATCC 33277, Peptostreptococcus anaerobius ATCC 27337. **Materiał I metody.** Badania przeprowadzono z użyciem następujących materiałów: AH Plus Jet (AH), Apexit Plus (AP), Endomethasone N (EN), Epiphany (EP), GuttaFlow (GF), Roeko Seal Automix (RSA), Sealapex (SP) i Tubliseal (TS). Działanie antybakteryjne świeżo zarobionych uszczelniaczy na wyżej wymienione szczepy bakterii badano z zastosowaniem metody dyfuzji agarowej. Po rozprowadzeniu zawiesiny bakteryjnej i aplikacji materiałów, płytki inkubowano w temperaturze 37°C przez 1 tydzień w atmosferze 5-10% by measuring the diameter of the growth inhibition zone after 48 h, 72 h, one week (F. nucleatum) or 72 h, 120 h and one week (P. gingivalis, P. anaerobius), and analyzed statistically using one-way analysis of variance (ANOVA) followed by post-hoc Tukey's test. **Results.** AH, EN, EP, SP and TS significantly inhibited all the bacterial strains over the experimental period. AP showed a slight suppressive effect on P. gingivalis only. No antimicrobial activity was detected for GF and RSA. **Conclusions.** The antimicrobial effect of root canal sealers varied considerably depending on the type of material and the tested bacterial species. Most of the sealers demonstrated antibacterial action on the investigated bacteria.CO2. Wyniki odczytywano mierząc strefy zahamowania wzrostu bakteryjnego po 48 h, 72 h, 1 tygodniu (F. nucleatum) lub 72 h, 120 h i 1 tygodniu (P. gingivalis, P. anaerobius), a następnie analizowano statystycznie z zastosowaniem jednoczynnikowej analizy wariancji ANOVA i testu post-hoc Tukey'a. **Wyniki**. AH, EN, EP, SP i TS znacząco hamowały wszystkie badane szczepy przez cały okres obserwacji. AP wykazał nieznaczne działanie hamujące tylko na P. gingivalis. Brak antybakteryjnej aktywności stwierdzono w przypadku RSA i GF. **Wnioski**. Przeciwdrobnoustrojowe działanie uszczelniaczy różniło się znacznie w zależności od rodzaju materiału i badanego szczepu bakteryjnego. Większość uszczelniaczy kanałowych wykazywała przeciwbakteryjną aktywność wobec badanych szczepów.

KEYWORDS: root canal sealers, antibacterial activity, agar diffusion test

Introduction

Microorganisms invading and colonizing the root canal system are the major etiologic agents of periradicular disease.1 Endodontic milieu with the necrotic pulp and low oxygen tension mainly supports the development of anaerobic microflora. Particular bacterial strains do not exist in the root canal as free-floating bacteria (planktonic microorganisms), but grow in the extracellular polysaccharide-protein matrix forming biofilms – well-organized, co-operating adherent microbial communities.2

Gram-negative anaerobic rods, such as Fusobacterium nucleatum, Porphyromonas gingivalis, and Gram-positive cocci as Peptostreptococcus species, are frequently isolated from the root canals of untreated teeth as well as filled roots with periapical lesions.3-7

Fusobacterium nucleatum is one of the most important anaerobic Gram-negative bacterium that can be closely associated with endodontic flare-ups. It is well known that lipopolysaccharide (LPS) contained in its cell wall is an endotoxin involved in the initiation of periapical inflammation and alveolar bone destruction.5,7 Yamasaki et al.8 demonstrated that F. nucleatum had a cytotoxic potential in periapical fibroblast cultures, and inhibited their growth and proliferation. In addition, this bacterium mediates significant aggregation of immune cells, which is directly correlated with induction of cell death.9

Moreover, F. nucleatum is regarded as a bridging organism in root canal biofilm due to some protein adhesins contained in the cell membranes, "bridging" together species which otherwise would not interact.10 It has been shown that this bacterium communicates with other microorganisms in the biofilm, e.g. Porphyromonas gingivalis, Peptostreptococcus micros, using a bacterial cell-to-cell communication mechanism (quorum sensing) for controlling cellular functions. It is known to be involved in the regulation of several microbial properties including virulence and resistance to anti-microbial agents, and therefore may increase the pathogenic potential of bacteria.5,8

Porphyromonas gingivalis is characterized by significant virulence due to a large number of putative virulence determinants such as lipopolysaccharide, fimbriae, capsule, lipoproteins and others.3 They can provoke inflammatory reactions, initiate tissue destruction and even perturb host defense mechanisms. Moreover, P. gingivalis is capable of resisting neutrophil phagocytosis by degradation of enzymes released from host defense cells, and also some immunoglobulins and complement factors.3 P. gingivalis is also able to initiate degradation of serum proteins and thus enable the growth of Fusobacterium and Peptostreptococcus, which cannot hydrolyze intact proteins despite producing peptidases.11 It would seem, therefore, that

Table 1. Compositions of materials tested for antibacterial activity

Name	Source	Active ingredients
AH Plus Jet™ (AH)	Dentsply DeTrey GmbH, Konstanz, Germany	Bisphenol-A epoxy resin, Bisphenol-F epoxy resin, Calcium tungstate, Zirconium oxide, silica, iron oxide pigments, dibenzyldiamine, aminoadamantane, tricyclodecane-diamine, silicone oil
Apexit® Plus (AP)	Ivoclar Vivadent AG, Schaan, Lichtenstein	Calcium salts (hydroxide, oxide, phosphate), hydrogenised colophony, disalicylate, bismuth salts (oxide, carbonate), highly dispersed silicon dioxide, alkyl ester of phosphoric acid

Endomethasone N (EN)	Septodont, Cedex, France	Zinc oxide, hydrocortisone acetate, thymol iodide, barium sulfate, magnesium stearate
Eugenol	Chema – Elektromet, Rzeszów, Poland	eugenol
Epiphany (EP)	Pentron® Clinical Technologies, LLC Wallingford CT, USA	Organic part: BisGMA, ethoxylated BisGma, UDMA, hydrophilic difunctional methacrylates Inorganic part: calcium hydroxide, barium sulphate, barium glass, bismuth oxychloride, silica
Gutta-Flow® (GF)	Coltene/Whaledent GmbH+Co. KG, Langenau, Germany	Gutta-percha powder, polidimethylosiloxane, silicone oil, platin catalyst, zirconium dioxide, nano-silver, coloring
Roeko Seal Automix (RSA)	Coltene/Whaledent GmbH+Co. KG, Langenau, Germany	Polydimethylsiloxane, silicone oil, paraffin-base oil, platinum catalyst, zirconium dioxide
Sealapex (SP)	Kerr Italia S.p.A., Salerno, Italy	Calcium oxide, bismuth trioxide, zinc oxide, sub-micron silica, 2% titanium dioxide, zinc stearate, tricalcium phosphate, blend
Tubli-Seal (TS)	Kerr Italia S.p.A., Salerno, Italy	Zinc oxide, barium sulfate, oleo resin, oils/modifiers, thymol iodide, eugenol

coexistence and synergistic associations with P. gingivalis, F. nucleatum, and Peptostreptococcus in root canal biofilm may constitute contributing agents in apical periodontitis.5,12

The ultimate goal of endodontic treatment, consisting of chemomechanical preparation and three-dimensional obturation of the root canal space, is the eradication of bacteria from the root canal system and prevention of subsequent reinfection. This enables achieving optimal conditions for healing of inflamed periradicular tissues after root canal treatment.1

It is well recognized that the huge majority of bacteria are sensitive to standard treatment procedures. Nevertheless, certain Gram-negative anaerobic species such as F. nucleatum, Prevotella and especially Gram-positive anaerobic cocci can be detected in post-instrumentation samples.1

Consequently, the use of root canal sealer with antibacterial activity may be advantageous in an effort to further eliminate residual microorganisms that have survived chemomechanical instrumentation, as well as to prevent recurrent reinfections.13-15

Thus, the aim of this in vitro study was to evaluate and compare the antimicrobial activity of currently used root canal sealers on three common endodontic pathogens: Fusobacterium nucleatum, Porphyromonas gingivalis, and Peptostreptococcus anaerobius.

Material and methods

Table 1 presents the materials used for the experiment and their composition. The standardized Peptostreptococcus anaerobius ATCC 27337, Fusobacterium nucleatum ATCC 25586, Porphyromonas gingivalis ATCC 33277 were obtained from Microbiologics, Inc., St. Cloud, Minnesota, USA. The strains were cultured on Schaedler agar (Emapol sp. z o.o., Gdańsk, Poland) supplemented with 5% of sheep blood and incubated for 24-72 hours at 370C under anaerobic conditions. The antibacterial activity of root canal sealers against the standardized strains of anaerobic bacteria was determined using the agar diffusion method on Brucella Blood Agar (Oxoid Limited, Hampshire, United Kingdom) enriched with 5% of sheep blood, vitamin K1 and 1% of hemin. After 24-

72 h, suspensions of bacterial strains in the Brucella broth of 1.0 of turbidity on the McFarland scale were prepared.

The bacterial suspension was distributed with a sterile cotton swab on the surface of Brucella Blood Agar with wells of 7 mm in diameter and 5 mm in depth. In order to seal up the wells, the bottom was covered with 10 µl of liquid Triptic Soya Agar (TSA) (Oxoid Limited, Hampshire, United Kingdom), and the wells were filled with freshly mixed sealers prepared in aseptic conditions according to the manufacturer's instructions. The plates were left in room temperature for 30 min. and then incubated for 48-72 hours in anaerobic conditions at 370C. To control the growth of the standardized strain on the agar used for the experiment, positive control plates were streaked with bacteria, but no root canal sealer was used. Six samples were prepared for each material.

The plates were examined and evaluated for growth inhibition zones at 48 hours, 72 hours, and 7 days (F.nucleatum) or at 72 hours, 120 hours, 7 days (P. gingivalis, P. anaerobius). The most uniform segment at the largest point of the growth inhibition zone was measured with a ruler and the results were given in millimetres. The 7 mm (diameter of the well) was extracted from the measurement as the cut-off value.15,16 Wider zones of inhibition were interpreted to indicate greater antimicrobial activity of the involved materials. Statistical analysis was performed using the Statistica 8.0 (StatSoft) software package. The collected data were statistically analyzed by comparing mean inhibition zone for each sealer. The obtained results were evaluated using one way analysis of variance (ANOVA) followed by Tukey's test and non-parametric Spearman's correlation coefficient. The level of significance was set at $p < 0.05$.

Results

The growth inhibition zones resulting from the application of different root canal sealers on the tested bacteria are shown in Figures 1-3. Most of the sealers (EN, SP, TS AH, and EP) showed antimicrobial activity on all tested bacterial strains. AP demonstrated antibacterial action only against P. gingivalis. GF and RSA were ineffective against all bacteria. Positive control plates showed bacterial growth in all cases. Analysis of variance revealed that the mean bacterial growth inhibition zone was significantly influenced by the tested material type ($p < 0.001$).

EN, followed by SP, TS, AH, AP and EP, exhibited the highest antibacterial effect against P. gingivalis. In relation to F. nucleatum, the average dimension of growth inhibition zones in descending order were detected with SP, TS, EN, AH, and EP. The largest growth inhibition zones for P. anaerobius were observed with EN and EP followed by TS, SP, and AH.

Statistical analysis of the results revealed significant differences between all the materials in the varying sizes of growth inhibition zones within particular strains. Details of the statistical analysis results are presented in Figures 1-3.

In order to compare the susceptibility of particular strains to each sealer, the mean growth inhibition zones obtained with all the measurements for each material (excluding materials with a zone of growth inhibition 0) were calculated and analyzed. Statistical analysis revealed that P. gingivalis was significantly more susceptible than F. nucleatum and P. anaerobius to AH, AP, and EN ($p<0.001$) and more susceptible than P. anaerobius to almost all tested sealers (except for EP). On the other hand, P.

anaerobius was significantly more susceptible than F. nucleatum and P. gingivalis to EP ($p<0.001$). F. nucleatum was significantly more susceptible than P. anaerobius to AH, SP, and TS ($p<0.001$) (Table 2).

The antibacterial effect of all the tested root

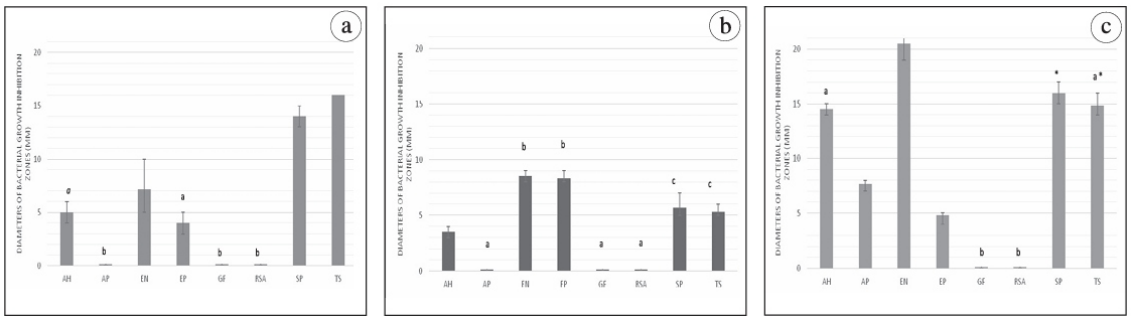

Fig. 1. Zones of bacterial growth inhibition in millimeters provided by root canal sealers; a – F. nucleatum at 48 hours, b – P. gingivalis at 72 hours, c – P. anaerobius at 72 hours.

All the values which have not been tagged with identical lowercase and symbols show statistically significant differences at a level of $p<0.001$;

The values which have been tagged with * are statistically significant at a level of $p<0.01$;

The values which have been tagged with identical lowercase a,b,c are not statistically significant ($p>0.05$).

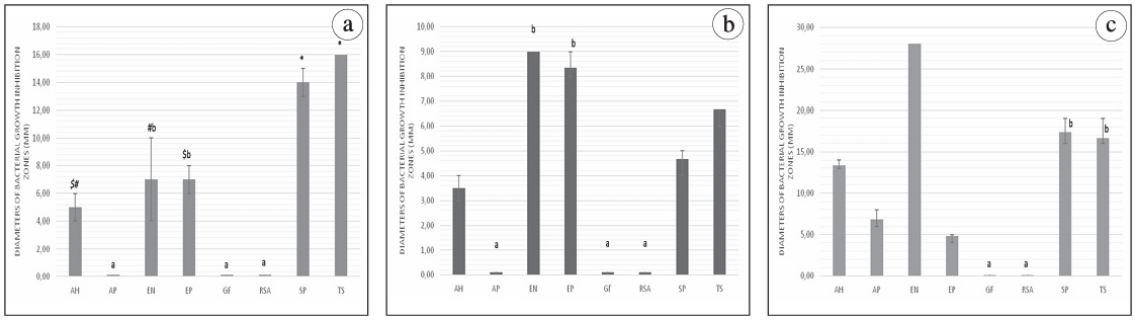

Fig. 2. Zones of bacterial growth inhibition in millimeters provided by root canal sealers; a – F. nucleatum at 72 hours, b – P. gingivalis at 120 hours, c – P. anaerobius at 120 hours.

All the values which have not been tagged with identical lowercase and symbols show statistically significant differences at a level of $p<0.001$;

The values which have been tagged with *$ # are statistically significant at a level of $p<0.01$;

The values which have been tagged with identical lowercase a,b are not statistically significant ($p>0.05$).

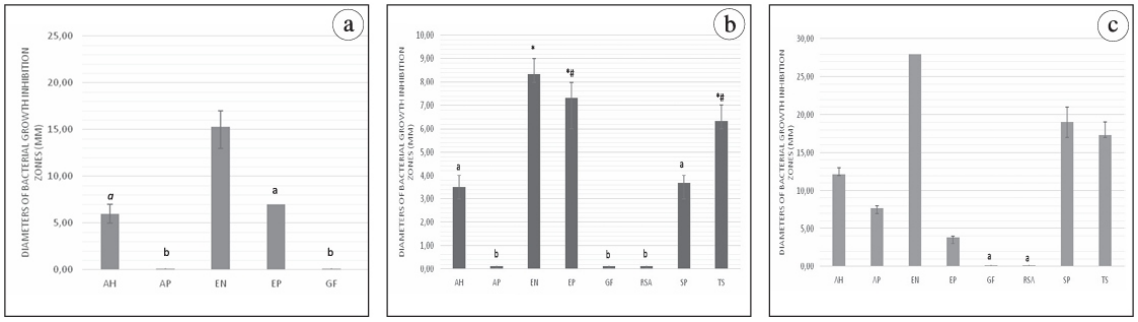

Fig. 3. Zones of bacterial growth inhibition in millimeters provided by root canal sealers at 7 days; a – F. nucleatum, b – P. gingivalis, c – P. ana erobius.

All the values which have not been tagged with identical lowercase and symbols show statistically significant differences at a level of p <0.001;

The values which have been tagged with * # are statistically significant at a level of p<0.01;

The values which have been tagged with identical lowercase a,b are not statistically significant (p>0.05).

Table 2. Mean bacterial growth inhibition zones from all periods of observations for each material (excluding materials showing no bacterial growth inhibition zone)

Material	Bacteria strain	Mean	SD	p	
AH	*F. nucleatum*	5.33	0.56	F. n. – P. a	p<0.001
	P. anaerobius	3.50	0.55	F. n. – P. g	
	P. gingivalis	13.33	0.42	P. a. – P. g	
AP	*F. nucleatum*	0	0	F. n. – P. a.	p=1.000
	P. anaerobius	0	0	F. n. – P. g	p<0.001
	P. gingivalis	7.39	0.49	P. a – P. g	p<0.001
EN	*F. nucleatum*	9.83	1.59	F. n. – P. a	p=0.061
	P. anaerobius	8.61	0.25	F. n. – P. g	p<0.001
	P. gingivalis	25.50	0.28	P. a – P. g	p<0.001
EP	*F. nucleatum*	6.00	0.37	F. n. – P. a	p<0.001
	P. anaerobius	8.00	0.56	F. n. – P.g	
	P. gingivalis	4.50	0.41	P. a – P. g	
SP	*F. nucleatum*	17.00	0.42	F. n. – P.a	p<0.001
	P. anaerobius	4.67	0.56	F. n. – P.g	p=0.919
	P. gingivalis	17.44	1.00	P. a – P. g	p<0.001
TS	*F. nucleatum*	17.00	0.21	F. n. – P. a	p<0.001
	P. anaerobius	6.11	0.34	F. n. – P. g	p=0.690
	P. gingivalis	16.28	0.74	P. a – P. g	p<0.001

SD – standard deviation; p – level of significance.

canal sealers against individual strains varied considerably during the entire experiment. For F. nucleatum, the antibacterial activity of the materials increased throughout the whole experiment. For P.gingivalis, the antibacterial effect of EN, TS, and SP rose, whereas with AH and EP it decreased gradually. The diameter of growth inhibition zones with AP remained stable over the experimental period. For P. anaerobius, only TS exhibited an enhancement of antibacterial activity. EN and AH were characterized by a stable increase of the growth inhibition zones, and the antibacterial effect of EP and SP decreased during the experiment.

Table 3 presents the results of correlation between the mean bacterial growth inhibition zones of the materials and the time of the experiment. Statistically significant correlations were found for all

microorganisms tested with EP, SP, TS and further for P. gingivalis with EN, AH, and also for F. nucleatum with EN ($p<0.05$).

Discussion

It has been proven that different bacteria may vary in their sensitivity to the same material.16 Therefore, it seems important to use more than one species of bacteria to test the antibacterial effect of root canal materials. Fusobacterium

Table 3. Spearman's non-parametric correlation between the means of bacterial growth inhibition zones for each material and the time of the experiment (excluding materials showing no bacterial growth inhibition zone)

Microorganism	Material	R	p	Correlation
Fusobacterium nucleatum	AH	0.45	p=0.064	moderate
	EN	0.74	**p=0.001**	**high**
	EP	0.78	**p<0.001**	**high**
	SP	0.76	**p<0.001**	**high**
	TS	0.85	**p<0.001**	**high**
Porphyromonas gingivalis	AH	-0.91	**p<0.001**	**high**
	AP	0.00	1.000	high
	EN	0.85	**p<0.001**	**high**
	EP	-0.69	**p=0.001**	**high**
	SP	0.79	**p=0.001**	**high**
	TS	0.84	**p<0.001**	**high**
Peptostreptococcus anaerobius	AH	0.00	p=1.000	high
	EN	-0.14	p=0.581	high
	EP	-0.54	**p=0.020**	**moderate**
	SP	-0.86	**p<0.001**	**high**
	TS	0.54	**p=0.022**	**moderate**

R – Spearman's rank correlation coefficient; p – level of significance; high correlation $r > 0.6$; moderate correlation $0.3 < r < 0.6$; low correlation $r < 0.3$.

nucleatum, Porphyromonas gingivalis, and Peptostreptococcus anaerobius have been shown to be frequently present in infected root canals and were, therefore, chosen as representatives for our study.3-7

It is extremely difficult to compare accurately bacterial inhibition data, even for identical materials, between different authors with the agar diffusion test due to difficulties in controlling the large number of variables. This means that there are no standardized in vitro protocols for testing the antimicrobial activity of materials.14

The findings of the present study have suggested substantial differences in the antimicrobial effect of root canal sealers. Among the materials tested, Endomethasone N, Tubliseal, AH Plus Jet, Epiphany and Sealapex showed antibacterial activity against all examined strains. These results are in accordance with previous findings evaluating the antibacterial effect of zinc oxide sealers and those based on epoxy resins on anaerobic bacteria.15-18 The antimicrobial effect of Endomethasone N and Tubliseal is attributed to free eugenol liberated from these sealers even after their setting. Eugenol, a phenolic compound, in relatively high concentrations inhibits the growth, or even induces death of bacterial cells.19 The adverse effect of AH Plus on bacteria might be related to the content of mutagenic bisphenol diglycidyl ether19 and epoxy amines.15 Taken together, these components made the epoxy resin sealers antimicrobial.

Epiphany, a polymethacrylate resin-based sealer, also inhibited the growth of all the tested bacterial anaerobic strains. The antimicrobial activity of this sealer can be possibly attributed to the toxicity of methacrylates and the release of unreacted and residual monomers.20,21 On the other hand, several authors have pointed out that the release of free monomers from materials characterized by a high water sorption, and thus high solubility such as Epiphany, might stimulate bacterial growth.22

Calcium hydroxide-containing sealers had a varied antibacterial effect. Apexit Plus was effective only on P. gingivalis, which is considered one of the most sensitive microorganisms.6 Other investigators also emphasized the poor antibacterial properties of Apexit Plus.13,16,17 It can be speculated that the increased pH resulting from the dissociation of calcium hydroxide into calcium and hydroxyl ions could have been responsible for any antimicrobial action of the calcium hydroxide sealers. The hydroxyl ions denature proteins of the cytoplasmatic membrane of bacteria, thus killing the cells.23 Our previous investigation has shown that Sealapex increased the pH of the environment considerably more than Apexit Plus, and thus potently inhibited the growth of all bacterial strains in the present study.24 These results are consistent with the findings of other authors.17,19,25 However, Ebert et al.26 presumed that the pH of calcium hydroxide sealers in culture media may not be high enough to suppress the growth of bacterial strains due to the buffering properties of the agar medium used.

It should be remembered that the antibacterial action of root canal obturative materials might be also modified by dentine.27 The influence of dentine on the antibacterial activity of certain drugs is associated with a buffering effect of this tissue.28

In the present experiment, RSA and GuttaFlow did not show an antibacterial effect against any of the tested microbial strains despite the fact that they contain antimicrobial components such as nano-silver particles (GuttaFlow).21 Cobankara et al.19 claimed that no antibacterial activity might be caused by insolubility and no diffusion of silicone materials in agar medium.

Our findings relating to polydimethylsiloxane materials are in agreement with previous studies.17,19,22,29 Willerhausen et al.,18 in turn, showed a weak antibacterial effect of GuttaFlow against P. micros. According to Nawal et al.,21 however, the nano-silver component added to this material might have acted as a preservative, but it does not contribute towards antimicrobial efficacy. The aforementioned differences may be caused by variations in methodologies.

The agar diffusion test is one of the most often used methods to assess and compare the antibacterial activity of root canal materials.13,15,17,19 To a certain extent, it helps to imitate a clinical situation

since agar, as well as dentine, has a buffering effect.26 Its main disadvantage is the inability to distinguish between the bactericidal and the bacteriostatic properties of the materials. In addition, the size of the inhibition zones not only depends on the antimicrobial agent content in the materials, but also on their solubility and diffusibility in an agar medium.19 Although the environment of root canals is dissimilar to the agar, bacteria can colonize the dentinal tubules, thus requiring the materials to have a high diffusion capability to be an effective antimicrobial agent.25

Conlusions

The present findings indicated that the antimicrobial activity of root canal sealers varied considerably depending on the type of material and the tested bacterial species. Most of the sealers demonstrated antibacterial action on Fusobacterium nucleatum, Porphyromonas gingivalis, and Peptostreptococcus anaerobius.

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ISSN: 0011-4553

Three-dimensional imaging in maxillofacial and plastic surgery

Trójwymiarowe obrazowanie w chirurgii szczękowo-twarzowej i chirurgii plastycznej

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ABSTRACT

Recent advances in technology have made three dimensional imaging and analysis possible. Different three-dimensional technologies such as 3-D cephalometry, morphoanalysis, moiré topography, multislice CT-assisted imaging, cone beam CT and MRI scanning, 3-D laser scanning and photographic modalities have been developed. None of these imaging techniques can alone capture and represent the true relationship between facial skeleton, soft tissue and dentition. Only image fusion models of different imaging techniques can create a 3-D virtual head displaying all of these elements. On the basis of such accurate 3-D face/head reconstruction a realistic prediction model of soft and hard tissues changes can be created Streszczenie Najnowsze osiągnięcia technologiczne sprawiły, że możliwe jest zarówno obrazowanie, jak i jego analiza w technologii trójwymiarowej. Opracowano różne jej typy, takie jak cefalometria 3D, analiza morfologiczna obrazu fotograficznego i radiologicznego, topografia mory, wielorzędowa tomografia komputerowa (CT), tomografia wiązki stożkowej (CBCT) oraz skanowanie MRI, skanowanie laserowe 3D, a także różnorakie metody robienia zdjęć. Jednak żadna z tych technik obrazowania nie może indywidualnie uchwycić I przedstawić prawdziwego związku pomiędzy twarzoczaszką, tkanką miękką a uzębieniem. Jedynie fuzja modeli obrazów z różnych technik obrazowania może pozwolić stworzyć wirtualny trójwymiarowy model głowy, przy jednoczesnym uwidocznieniu wszystkich wymienionych elementów. Na podstawie tak dokładnej trójwymiarowej rekonstrukcji twarzy/ głowy można stworzyć realistyczny model predykcyjny zmian następujących w tkankach miękkich I tkankach twardych.

KEYWORDS:
maxillofacial surgery, 3-D imaging, 3-D model, 3-D reconstruction, face

Introduction

For the past decades, plastic, maxillofacial surgeons and orthodontists used photographs and conventional radiographs for treatment planning. These methods determined current understanding

Wprowadzenie

Przez ostatnie dziesięciolecia chirurdzy plastyczni oraz chirurdzy szczękowo-twarzowi, a także ortodonci, wykorzystywali zdjęcia I konwencjonalną radiografię jako podstawę służącą of facial aesthetics and proportion. Various ratios and measurements obtained from the profile and frontal view

that characterize aesthetically desired face proportion have been described.1,2 Despite the passage of time, pre-operative and post-operative cephalometric analysis of hard tissues, basing on cephalograms and photographs, is still frequently performed. These techniques limit the quantitative assessment of hard and soft tissue changes solely to the midsagittal plane. Only linear distances, angles and areas can be measured.3,4 Such assessment is also connected with bias arising from representing three-dimensional (3-D) objects (anatomical structures of the head/face) on a two-dimensional (2-D) image. Despite such shortcomings, many 2-D surgical treatment planning computer programs, based on both bone and soft tissue analysis, have been developed. Evaluation concerning the three-dimensional anatomy of the patient has traditionally been limited to physical examination and to the analysis of dental study plaster models. Due to recent advancement in technology three-dimensional imaging and analysis is possible. Emerging 3-D methods of anatomical structure acquisition include threedimensional cephalometry, morphoanalysis, moiré topography, computer tomography-assisted 3-D imaging, 3-D ultrasonography, 3-D laser scanning and stereophotogrammetry. Lately, methods based on image fusion of different imaging techniques have been extensively developed, being especially valuable in orthognathic surgery and orthodontics. New software systems offer new possibilities for surgeons and orthodontists to plan, perform and assess the treatment outcomes. Potential clinical utilities of reviewed methods are presented in Table 1.5-19

The above-mentioned applications necessitate sufficient accuracy in reliable representation of anatomical structures of the head/face and the neck. Some studies validating the reproducibility of identifying landmarks of 3-D imaging proved that the accuracy is relatively high and its values range from 0.2 to 1 mm (depending on the applied method).3,20-25 Due to the fact that these techniques are fairly new, the normative data of craniofacial structures including hard and soft tissues are do planowania leczenia. Metody te umożliwiły obecny sposób rozumienia proporcji oraz estetyki twarzy. Opisano również różnorakie stosunki oraz pomiary pozyskane dzięki widokowi z boku oraz z przodu, które charakteryzują proporcje twarzy pożądane pod względem estetycznym.1,2 Pomimo upływu czasu, nadal niezwykle często wykonuje się przedzabiegową i pozabiegową analizę cefalometryczną tkanek twardych, bazując na cefalogramach i zdjęciach. Techniki te ograniczają ilościową ocenę zmian w tkankach twardych I tkankach miękkich wyłącznie do płaszczyzny środkowej. Możliwe jest zmierzenie jedynie odległości liniowych, kątów, a także powierzchni.3,4 Tego rodzaju ocena wiąże się również ze stronniczością wynikającą z trójwymiarowego (3D) przedstawiania obiektów (struktur anatomicznych głowy/twarzy) na dwuwymiarowym (2D) obrazie. Pomimo tak poważnych braków, powstało wiele programów komputerowych umożliwiających planowanie leczenia chirurgicznego na poziomie 2D, bazujących na analizie obejmującej kość i tkankę miękką. Ocena dotycząca trójwymiarowej anatomii pacjenta była tradycyjnie ograniczona do badania fizykalnego, jak również do analizy gipsowych diagnostycznych modeli dentystycznych. Dzięki ostatnim osiągnięciom w zakresie technologii możliwe jest zarówno obrazowanie, jak I analiza trójwymiarowa. Nowo powstałe trójwymiarowe metody obrazowania struktury anatomicznej obejmują cefalometrię 3D, analizę morfologiczną obrazu fotograficznego i radiologicznego, topografię mory, obrazowanie 3D wspierane tomografią komputerową, ultrasonografię 3D, skanowanie laserowe 3D oraz stereofotogrametrię. W ostatnim czasie widać niezwykły rozwój metod opierających się na fuzji obrazów z różnych technik obrazowania, co jest szczególnie cenione zwłaszcza w chirurgii ortognatycznej, a także w ortodoncji. Nowe oprogramowania oferują nowe możliwości zarówno chirurgom, jak i ortodontom, dając im pole do planowania, przeprowadzania, a także oceniania wyników leczenia. Potencjalna użyteczność kliniczna metod objętych przeglądem została przedstawiona w tabeli 1.5-19

Wymienione aplikacje wymagają właściwej dokładności w zakresie wiarygodnego odzwier

Table 1. Potential clinical applications of three-dimensional imaging techniques

Authors	Method used	Clinical application	Study design
Ferrario et al.[5]	Stereophotogrammetry	Assessment of appearance of changes related to growth	Mesh diagram analysis of 3-D coordinates of 50 soft tissue landmarks. Study group: 591 people (351M and 240F; 6-40 years old)
Akazaki et al.[6]	3-D laser scanning	Assessment of appearance of changes related to aging	3-D morphometric analysis of depth and width of skin wrinkles. Study group: 101 women (20-80 years old)
Nute and *Moss*[7]	3-D laser scanning	Assessment of gender and age-related dimorphism of appearance	3-D coordinates of soft tissue landmarks. Study group: 132 children (5-10 years old)
Giovanoli et al.[8]	3-D video analysis system	Assessment of facial expressions of emotions	Study group: 24 people (22-70 years old)
Gur et al.[9]	3-D video analysis, stereophotogrammetry (4 digital cameras and a camcorder)	Assessment of facial expressions of emotion	Digital database of 3-D photographs of actors displaying facial expressions of different emotions and intensity levels for use in neurocognitive studies. Study group: 139 people (70M and 69F)
Okada[10]	3-D laser scanning	Assessment of facial expressions	Quantitative measurements of angles and areas associated with function of mimetic muscles during facial expressions. Study group: 7 healthy volunteers and 3 patients with nerve palsy
Khambay et al.[11]	Fusion method, stereophotogrammetry and 3-D spiral CT	Monitoring and assessment of surgery outcome	Assessment of soft tissue changes after orthognathic surgery
Ferrario et al.[12]	Stereophotogrammetry	Monitoring and assessment of surgery outcome	Different methods of images superimposition were compared. Assessment of soft tissue changes after orthognathic surgery. Study group: 20 patients (14M, 6F), 8-26 years old
Moss et al.[13]	3-D laser scanning	Monitoring and assessment of surgery outcome	Assessment of soft tissue changes related to bone remodeling after tooth extraction in comparison with non-treatment group. Study group: 16 non-extraction and 18 extraction patients
Ferrario et al.[14-17]	Stereophotogrammetry	Monitoring and assessment of surgery outcome	Quantitative 3-D assessment (on the basis of calculating specific distances, areas, volumes with a set of certain landmarks) of soft tissue facial asymmetry in adult patients after cleft lip and palate surgery
Ji et al.[18]	3-D laser scanning	Planning of facial reconstruction	Planning a reconstruction of burn defect with flap surgery. One patient with scar contracture of the face
Xia et al.[19]	CT – assisted 3-D imaging	Surgery planning	3-D virtual reality surgical planning and simulation of orthognathic surgery with visualization of osteotomy and soft tissue changes

M – male, F – female.

limited. Nevertheless, there are some studies that provide some standards and norms.5,26

Methods of three-dimensional imaging

2.1 Three-dimensional cephalometry

This technique is based on two standardized cephalograms performed in lateral (LAT) and posteroanterior (PA) projection. From a set of 2-D rentgenographic images an analysis of 3-D form can be performed.27 A set of reconstructed 3-D landmarks could be presented by means of a wire frame.27 Many modifications have been applied and several computer programs have been developed since the very first introduction of this method.27-31 The main advantage of this method is that it has an available normative database and involves low radiation dose. Unfortunately, locating the same landmarks is still difficult. Moreover, hard and soft tissues assessment is limited to the midsagittal plane.

2.2 Morphoanalysis

This method of three-dimensional head reconstruction is based on superimposition of photographs on radiographs. The position of the patient's head is standardized according to three Cartesian reference planes. Two stereo pairs of videocameras, one stereo pair at each side of the patient's face, are used. This allows precise measurement of anatomical landmarks. Nonetheless, high cost of equipment is seen as a great disadvantage of this method.4

2.3 Moiré topography

This optical method for three-dimensional quantitation utilizes moiré pattern that appears after distortion of projecting a straight-line grid on the facial surface. This moiré fringe pattern can be detected by a camera or video camera and coordinates of any point on the face can be obtained. In 3-D head modeling, laser grating is applied to the face, and computer program can detect moiré fringes and use them to create a 3-D model.32 This method is useful in obtaining digital 3-D dental model from dental plaster cast.33 Unfortunately, this method is not sufficient as far as detecting sharp features is concerned, and ciedlania struktur anatomicznych głowy/twarzy oraz szyi. Niektóre z badań oceniających odtwarzalność pod kątem identyfikacji punktów odniesienia obrazowania 3D dowiodły, że dokładność jest stosunkowo duża, a jej wartość waha się od 0,2 do 1mm (w zależności od zastosowanej metody).3,20-25 Normatywne dane w zakresie struktur twarzowo-czaszkowych obejmujące tkanki twarde i miękkie są ograniczone, ponieważ techniki te są jeszcze stosunkowo nowe. Mimo wszystko, istnieją pewne badania, które dają określone standardy I normy.5,26

Metody obrazowania trójwymiarowego

2.1. Cefalometria trójwymiarowa

Powyższa technika opiera się na dwóch znormalizowanych cefalogramach wykonanych w projekcji bocznej (LAT) I tylno-przedniej (PA). Na podstawie zestawu obrazów rentgenograficznych 2D można przeprowadzić analizę formy 3D.27 Zestaw odtworzonych punktów odniesienia 3D można przedstawić w formie drucianej siatki.27 Od czasu pojawienia się tej metody wprowadzono wiele modyfikacji, jak również opracowano sporą liczbę programów komputerowych jej dotyczących..27-31 Główną przewagą tej metody jest fakt, iż oferuje ona dostęp do normatywnej bazy danych, co więcej, wiąże się z niską dawką promieniowania. Niestety, umiejscowienie tych samych punktów odniesienia jest nadal trudne. Ponadto, ocena twardych i miękkich tkanek ogranicza się do płaszczyzny środkowej.

2.2. Analiza morfologiczna obrazu fotograficznego I radiologicznego

Ta metoda trójwymiarowej rekonstrukcji głowy bazuje na nałożeniu fotografii na radiogramy. Pozycja

głowy pacjenta jest znormalizowana zgodnie z trzema referencyjnymi płaszczyznami kartezjańskimi. Wykorzystuje się tutaj dwie pary wideokamer stereo, po każdej stronie twarzy pacjenta znajduje się jedna para kamer. Pozwala to na precyzyjne zmierzenie anatomicznych punktów odniesienia. Niemniej jednak, wysoki koszt sprzętu stanowi sporą niedogodność tej metody.4

it does not include information concerning 3-D bone structure. This technique is also vulnerable to changes in head positioning. Moreover, survey preparation is time consuming.34

2.4 Three-dimensional ultrasonography

Three-dimensional ultrasonography is a useful technique in tissue imaging, however currently has a limited application in orthognathic and facial plastic surgery. Soft tissue facial scanning is performed with a special probe that comes into contact with the skin, which is covered with a special gel. Although this technique is not expensive and is safe for the patient, it has too many disadvantages to be used routinely. Threedimensional ultrasonography gives no information about the texture of the surface, the survey is time consuming and the acquired data can be confounded by surface compression.35

2.5 Three-dimensional laser scanning

This method is based on projecting known patterns of light to infer an object's shape. A laser beam reflected from the facial surface is distorted in a way which corresponds to facial topography. This reflection is registered by a digital camera. Many systems utilizing methods based on projection of a bright spot of light, a stripe of light (these techniques are called serial methods – they need to scan the whole object to get the whole shape) have been developed, not to mention methods using a 2-D pattern of light that can be projected to cover the scene (parallel light stripes, colored stripes, a grid of dots). Diversity of available scanning systems includes those with a fixed light source (the scanned object needs to be rotated), systems with a set of fixed light sources, as well as systems with rotated light sources.36 There are also systems that facilitate scanning an object from any direction, due to a set of cameras detecting the laser light and electromagnetic sensors detecting the orientation and position of the device in relation to the scanned object. Three-dimensional laser scanning is a very useful and accurate method not only for capturing the soft tissue, but also for visualizing the dentition. Three-dimensional dental model is obtained after

2.3. Topografia mory

Ta optyczna metoda kwantyfikacji trójwymiarowej wykorzystuje wzorzec prążków mory, który pojawia się po zniekształceniu siatki z linii prostych wyświetlanej na powierzchni twarzy pacjenta. Ten wzorzec odkształcenia prążków mory można wykryć za pomocą aparatu lub kamery video i można uzyskać współrzędne każdego punktu na powierzchni twarzy. Jeśli chodzi o trójwymiarowe modelowanie głowy, na twarz nakłada się siatkę laserową, a program komputerowy może wykryć zniekształcenia prążków mory i wykorzystać je do stworzenia modelu trójwymiarowego.32 Metoda ta okazuje się skuteczna w zakresie uzyskiwania cyfrowego stomatologicznego modelu 3D ze stomatologicznego odlewu gipsowego.33 Niestety, metoda ta jest niewystarczająca, jeśli chodzi o wykrywanie punktów szczytowych, jak również nie zawiera informacji dotyczących struktury kostnej 3D. Technika ta jest także podatna na zmiany w zakresie ułożenia głowy. Co więcej, przygotowanie projektu jest niezwykle czasochłonne.34

2.4. Ultrasonografia trójwymiarowa

Ultrasonografia trójwymiarowa jest techniką przydatną w zakresie obrazowania tkanki, niemniej jednak, obecnie ma ona ograniczone zastosowanie w chirurgii ortognatycznej I chirurgii plastycznej twarzy. Skanowanie tkanki miękkiej w obrębie twarzy wykonuje się za pomocą specjalnej sondy, która ma styczność ze skórą, pokrytą specjalnym żelem. Mimo, iż technika ta nie należy do drogich, a także jest bezpieczna dla pacjenta, charakteryzuje się zbyt dużą liczbą niedogodności, aby mogła być wykorzystywana w rutynowy sposób. Trójwymiarowa ultrasonografia nie daje żadnych informacji na temat faktury powierzchni, przygotowanie jej jest niezwykle czasochłonne, a uzyskane dane może zakłócić kompresja powierzchni.35

2.5. Skanowanie laserowe 3D

Metoda ta opiera się na wyświetlaniu znanych wzorów światła, które pozwalają wywnioskować kształt danego obiektu. Wiązka laserowa odbija się od powierzchni twarzy i zniekształca się w sposób odpowiadający topografii twarzy. Właśnie to odbi

scanning dental plaster cast or a wax bite.37,38 Obtaining such a 3-D model requires preparation of the plaster cast. Some researchers, however, designed a method that does not require destruction of dental casts.39 With the use of laser scanning there is also a possibility to obtain digital dental model by direct intraoral scanning of the patient's teeth in occlusion with the help of an intraoral scanning device and a dedicated spray. Although this modification facilitates obtaining digital dentition model without plaster cast or impression, it is inconvenient when used in everyday practice. Limitation on the wide use of this technique in soft tissue imaging is connected with long acquisition time (even up to 30s), depending on the laser scanner that is being used, and this increases the risk of movement confounders. Moreover, to achieve colored facial texture an expensive set with multiple laser beams is needed. This method is sensitive to light and the presence of metal objects.

2.6 Stereophotogrammetry (3-D photography)

This is an optical method, which gives the opportunity to use photographs to estimate the three-dimensional coordinates of points on the object. It requires taking at least two photographs from different positions. Then, common landmarks are identified on each image. Since the position of cameras and their focal length in relation to the object is known due to triangulation, it is also possible to determine the location of points. To obtain a more accurate 3-D model more than two cameras can be used. 3-D stereophotogrammetry is a reliable and valuable tool with no side effects for the patient. Other advantages include relatively low costs of the method and quick capture speed. This method enables not only the creation of a model based on 3-D coordinates, but it also provides realistic colour and texture data for computer-generated 3-D shape.40

2.7 Three-dimensional video imaging

This technique is similar to stereophotogrammetry; the only difference lies in the fact that video cameras are used instead of cameras.41

cie zostaje zarejestrowane przez kamerę cyfrową. Opracowano wiele systemów wykorzystujących metody opierające się na wyświetlaniu jasnej plamki świetlnej, wiązki światła (techniki te nazywane są metodami seryjnymi – konieczne jest przeskanowanie całego obiektu, aby uzyskać całkowity kształt), nie wspominając o metodach wykorzystujących dwuwymiarowy wzór świetlny, który można wyświetlić pokrywając całą powierzchnię (równoległe wiązki światła, kolorowe wiązki, raster

punktowy). Różnorodne dostępne obecnie systemy skanowania obejmują systemy ze stałym źródłem światła (skanowany obiekt musi być obracany), systemy składające się z zestawu stałych źródeł światła, jak również systemy z obrotowym źródłem światła.36 Istnieją również systemy, które ułatwiają skanowanie obiektów z każdej strony, gdyż są wyposażone w zestaw kamer wykrywających światło lasera, jak również czujniki elektromagnetyczne wykrywające ustawienie i pozycję urządzenia w stosunku do skanowanego obiektu. Trójwymiarowe skanowanie laserowe jest niezwykle przydatną i bardzo dokładną metodą służącą nie tylko do odzwierciedlenia tkanki miękkiej, ale również do wizualizacji całego uzębienia. Trójwymiarowy model stomatologiczny uzyskuje się po skanowaniu odlewu stomatologicznego lub odcisku z wosku.37,38 Uzyskanie takiego modelu 3D wymaga przygotowania odlewu gipsowego. Niemniej jednak, niektórzy badacze odkryli metodę, która nie wymaga niszczenia odlewów stomatologicznych.39 Za pomocą skanowania laserowego można również uzyskać cyfrowy model stomatologiczny dzięki skanowaniu uzębienia pacjenta podczas zgryzu wewnątrz jamy ustnej, co z kolei jest możliwe dzięki wykorzystaniu specjalnego urządzenia skanującego wnętrze jamy ustnej oraz odpowiedniego aerozolu. Mimo, iż powyższa modyfikacja ułatwia uzyskanie cyfrowego modelu uzębienia bez konieczności wykonywania odlewu lub odcisku, jest stosunkowo niewygodna podczas wykonywania codziennej praktyki. Ograniczenia związane z powszechnym użyciem tej techniki w zakresie obrazowania tkanki miękkiej wiążą się z długim czasem pobierania danych (nawet do 30s), w zależności od użytego skanera, a to zwiększa ryzyko przesunięcia się potencjalnych czynników zakłócających. Co więcej, aby uzyskać barwną struk

2.8 Computed tomography-assisted three-di
mensional imaging

Sequential axial CT scans can be reconstructed to produce life-size head model. Many approaches for creating facial skeleton reconstructions have been applied. Three-dimensional milled model, stereolitographic model and two-stage resin model have been proposed.42-50 Although such facial skeleton models allow three-dimensional assessment of anatomical structures and deformities, next to performing model surgery, they do not provide the possibility to visualize and simulate soft tissue changes.51-55 On the basis of two-dimensional cross-sectional CT scans 3-D digital reconstruction of facial skeleton can be also performed.

The quality of images acquired with computed tomography is high, but the position of image acquisition is horizontal, and this affects the face proportion and natural shape of soft tissues. Moreover, this method is expensive and requires high radiation dose, which is connected with the appearance of streak artifacts.56 Some authors used this method not only to obtain a 3-D skeleton model but also to create a dental model after scanning dental impressions.38

2.9 Cone-beam computed tomography (CBCT)

In comparison with multislice CT, this technique utilizes a lower dose of ionizing radiation, it is cheaper and much more accessible. Position of image acquisition is vertical and the head and soft tissues can be captured in a neutral position. This method is used to visualize skeleton and dentition. Digital dental cast can be obtained in two different methods with the use of CBCT. The first one is based on scanning dental plaster cast or dental impression and is connected with pouring the cast.38,57 The second one is based on rendering a 3-D dental model from DICOM images of the patient. This method is vulnerable to metal artifacts.57,58

2.10 Magnetic resonance imaging (MRI) This method is safe (no ionizing radiation) and accurate in imaging soft tissues. High cost, horizontal position of image acquisition and turę twarzy, konieczne jest użycie drogiego zestawu z wielokrotnymi wiązkami laserowymi. Metoda ta jest wrażliwa na jasne i metalowe przedmioty znajdujące się w miejscu wykonywania procedury.

2.6. Stereofotogrametria (zdjęcia 3D)

Jest to metoda optyczna, która daje możliwość wykorzystania zdjęć do oszacowania trójwymiarowych współrzędnych punktów w badanym obiekcie. Metoda ta wymaga wykonania co najmniej dwóch zdjęć z dwóch różnych pozycji. Następnie, na każdym obrazie rozpoznaje się wspólne punkty odniesienia. Ponieważ pozycja aparatów i ich ogniskowych w stosunku do badanego obiektu jest znana dzięki triangulacji, możliwe jest również określenie umiejscowienia poszczególnych punktów. Aby uzyskać dokładny model 3D, można wykorzystać więcej niż 2 aparaty. Stereofotogrametria 3D to wiarygodne I wartościowe narzędzie, które nie wiąże się z żadnymi efektami ubocznymi dla pacjenta. Inne korzyści wynikające z tej metody to stosunkowo niski koszt i szybkość przechwytywania danych. Powyższa metoda daje możliwość nie tylko stworzenia modelu opartego na współrzędnych 3D, ale również przedstawia rzeczywiste dane dotyczące koloru oraz struktury trójwymiarowego kształtu wygenerowanego komputerowo.40

2.7. Obrazowanie 3D

Technika ta jest podobna do stereofotogrametrii; jedyna różnica polega na tym, że zamiast aparatów fotograficznych wykorzystuje się tutaj kamery video.41

2.8. Obrazowanie trójwymiarowe wspierane tomografią komputerową

Obrazy sekwencyjnej osiowej tomografii komputerowej można rekonstruować, aby opracować komputerowy model głowy naturalnej wielkości. Zastosowano wiele prób w celu stworzenia rekonstrukcji twarzoczaszki. Opracowano frezowany model trójwymiarowy, model stereolitograficzny oraz model z żywicy nowolakowej.42-50 Mimo, iż tego rodzaju modele twarzoczaszki pozwalają na trójwymiarową ocenę struktur anatomicznych oraz deformacji anatomicznych, a nawet umożli long acquisition time (the risk of movement artifacts) makes it impractical for regular application in facial plastic surgery, orthodontic and orthognathic treatment planning. Moreover, the bone data are not accurate enough for skeletal reconstruction.59-61

The above-mentioned methods rely on imagebased approaches in 3-D face reconstruction. There are also methods utilizing a model-based idea.

2.11 Model-based face reconstruction

These techniques use models of human face with some characteristic features that can be deformed to align specific facial shapes and expressions. Most such methods of 3-D facial imaging are based on Candide Model – a parametrized facemask that contains 113 vertices and 184 triangles on the human face.62

2.12 Image fusion models

Lately, for more accurate head model reconstruction image fusion techniques have been extensively developed. This approach is especially valuable in orthognathic and orthodontic field, as it facilitates accurate analysis of three important components of the patient's face influenced by the treatment. Such a 3-D fusion head model is realistic, accurate and represents the true relationship between facial

skeleton, soft tissue and dentition. Different matching methods are used to fuse 3-D data, and different sets of imaging methods are used to reconstruct the final 3-D head model. Possible fusion models are presented in Table 2.4,11,20,27,29,,38,53,57,63-80

wiają przeprowadzenie zabiegu na danym modelu, nie dają jednak możliwości dokonania wizualizacji i symulacji zmian zachodzących w tkankach miękkich.51-55 Trójwymiarową, cyfrową rekonstrukcję twarzoczaszki można również przeprowadzić w oparciu na dwuwymiarowych obrazach uzyskanych podczas skanowania w płaszczyźnie poprzecznej. Jakość obrazów uzyskanych dzięki tomografii komputerowej jest wysoka, aczkolwiek pozycja niezbędna do uzyskania obrazu to pozycja horyzontalna, co ma wpływ na proporcje twarzy, a także naturalny kształt tkanek miękkich. Ponadto, powyższa metoda jest kosztowna i wymaga dużej dawki promieniowania, co wiąże się z kolei z pojawieniem się artefaktów linijnych.56 Niektórzy autorzy wykorzystywali tę metodę nie tylko, aby uzyskać trójwymiarowy model szkieletu, ale również, aby stworzyć model stomatologiczny po zeskanowaniu wycisków stomatologicznych.38

2.9. Tomografia wiązki stożkowej (CBCT)

W porównaniu do wielorzędowej tomografii komputerowej, technika ta wykorzystuje niższą dawkę promieniowania jonizującego, jest tańsza i o wiele bardziej dostępna. Pozycja podczas pozyskiwania obrazu to pozycja pionowa, w związku z czym głowa i tkanki miękkie mogą zostać uchwycone w pozycji neutralnej. Metoda ta jest wykorzystywana do wizualizacji szkieletu oraz uzębienia. Istnieją dwa sposoby pozyskania cyfrowych odlewów stomatologicznych przy zastosowaniu CBCT. Pierwszy z nich opiera się na skanowaniu stomatologicznego odlewu gipsowego lub wycisku stomatologicznego i wiąże się z koniecznością wykonania samego odlewu.38,57 Drugi sposób bazuje na przedstawieniu trójwymiarowego modelu stomatologicznego na podstawie obrazów cyfrowych DICOM pacjenta. Metoda ta jest wrażliwa na artefakty ze strony obiektów metalowych.57,58

2.10. Rezonans magnetyczny (MRI)

Ta metoda jest bezpieczna (brak promieniowania jonizującego), co więcej, jest dokładna, jeśli chodzi o obrazowanie tkanek miękkich. Wysoki koszt, horyzontalna pozycja podczas pozyskiwa

Table 2. Comparison of different fusion methods of 3-D imaging.

Authors	Imaging methods			Bite registration	Registration method
	Facial skeleton	Soft tissue	Dentition		
Moate et al.[63]	Lateral cephalogram	2-D photo	None	None	Point based
Method description. 2-D photos are superimposed on the cephalogram and virtual patient model is created.					
Advantages. Low dose of ionizing radiation. Easy to perform			**Disadvantages.** Purely 2-D technique.		
Marchetti et al.[64]	CT, cephalogram	None	None	None	Point based
Method description. 3-D model of hard and soft tissue is generated based on CT scan and cephalogram.					
Advantages. Accurate and realistic method.			**Disadvantages.** High dose of ionizing radiation, lack of detailed information about dentition.		

Aoki et al.[65]	Frontal and lateral cephalograms		None	None	Point based
Method description. 3-D model is built based on 3-D photographs and on the basis of anatomical knowledge. The change within the shape of the facial surface was predicted in 3-D. The predicted result was compared to the actual result (patient after surgery) and then evaluated.					
Advantages. Low dose of ionizing radiation. Easy to perform.			**Disadvantages.** Low accuracy.		
Tsuji et al.[66]	Frontal and lateral cephalograms	None	3-D laser scanning of dental cast	Plaster dental cast	Point based
Method description. Data concerning facial skeleton and dentition are used for intraoperative navigation system based on optical tracking system with video cameras and light-emitting diodes (two video cameras follow the 3-D coordinates of LED assemblies attached to the head, lower jaw and the handpiece).					
Advantages. Navigation system facilitates performing the surgery.			**Disadvantages.** Time-consuming, information concerning soft tissues limited to the midsagittal plane.		
Grayson et al.[27]	Frontal and lateral cephalograms	None	None	None	None
Method description. Method is based on simulation of stereophotogrammetry using only cephalogram images.					
Advantages. Low dose of radiation, simple and practical for quantitative or long-term serial analysis.			**Disadvantages.** Inability to represent curving form in three dimensions, soft tissues assessment limited to the midsagittal plane.		
Baumrind et al.[29]	PA and lateral cephalograms	None	3-D virtual dental cast	Plaster dental cast	

Method description. Different methods of superimposition are implemented. The first type of superimposition involves a tooth-by-tooth registration. The second superimposition is a 3-D analog of cephalometric superimposition‘on “best fit” of palatal anatomy’ or‘on mandibular border’. Such superimpositions are based on specific biological information about the regions of growth and of relative stability within the human jaws. The third type of superimposition is designed to permit quantitization of changes in the positional relationship of each jaw and its contained teeth with respect to biologically stable structures of the skull as represented by the bony base of the anterior cranial fossa.

Advantages. Low dose of ionizing radiation.

Disadvantages. The fusion process is time consuming. This is a semi 3-D technique.

Ayoub et al.[4]	Frontal and lateral cephalograms	Stereo pair of video cameras	None	None	Point based
Method description. Two stereo pairs of video cameras at each side of the patient’s face allow a rapid capture of the face in three dimensions and a cephalogram almost simultaneously, enabling a more accurate superimposition of soft and hard tissues. This system can be used for precise measurement of anatomic landmarks.					
Advantages. Low dose of ionizing radiation.			**Disadvantages.**		

Table 2. cont

Authors	Imaging methods			Bite registration	Registration method
	Facial skeleton	Soft tissue	Dentition		
Nakasima et al.[67]	Frontal and lateral cephalograms	3-D photo	CT scanned dental cast	Plaster dental cast	Point based
Method description. The 3-D reconstruction of a person’s head was performed by fitting the prototype standard head model with an individual one based on the data obtained from cephalograms, photos and digital dental cast. The least squares method was also used in the triangle-matching procedure.					

Advantages. Low dose of ionizing radiation, accurate method.			**Disadvantages.** Registration errors caused by differences in head positioning, different facial expressions and artifacts during images acquisition.		
Noguchi et al.[68]	3-D cephalometry	Laser scanning	3-D laser scan of dental cast	Plaster dental cast	Surface based
A projection-matching technique is used to integrate soft tissue, skeleton and dentition data. The mandibular form is simulated by transforming a generic model to match the patient's cephalometric data.					
Advantages. Low dose of ionizing radiation, accurate method.			**Disadvantages.** Registration errors caused by differences in head positioning, Different facial expressions and artifacts during images acquisition.		
Gateno et al.[69]	CT	None	3-D laser /CT scanning of dental cast	Plaster dental cast	Based on the fiducial markers
Method description. Registration method is performed with the use of fiducial markers. All surgical procedures could be planned/tested on a virtual model.					
Advantages. Good visualization of the interocclusal relationship.			**Disadvantages.** Fusion process is time consuming, high dose of ionizing radiation, expensive		
Nkenke et al.[53]	CT	None	3-D optical scan of dental cast and CT scan of dental cast	Plaster dental cast	Based on the fiducial markers
Method description. Two CT and 3-D optical scans of plaster cast with and without metal restoration were performed. Differences between these images were calculated. Then CT scans of the patient were acquired. Collected data were used to create 3-D simulation model.					
Advantages. Good visualization of the interocclusal relationship.			**Disadvantages.** Fusion process is time consuming, expensive, with high dose of ionizing radiation; the accuracy of optical 3-D surface scanning of dental arches is significantly reduced by metal artifacts.		
Schutyser et al.[57] *Swennen* et al.[70]	CT	None	CT scan of dental cast	Plaster dental cast	Point based with a splint with markers
Method description. This is a double scan technique of acquisition dental occlusion. During the first CT scan patient wears the splint between upper and lower teeth. Then, the splint is positioned between plaster casts of the upper and lower jaw, and this setup is scanned. Based on markers in the 3-D splint, both data sets are fused and a combined visualization is possible.					
Advantages. Good visualization of the interocclusal relationship.			**Disadvantages.** Fusion process is time consuming, high dose of ionizing radiation, expensive.		
Swennen et al.[71]	CT	None	CT scan of wax impression	wax impression/wax wafer	Point based
Method description. Virtual skull model is created on the basis of CT skeletal scans. Impressions of the upper and lower arches and the wax bite wafer are scanned using a high-resolution standardized multislice CT. Automatic rigid point-based registration is used to implement the digital virtual dental arches into the patient's skull model.					
Advantages. High accuracy, good visualization of the interocclusal relationship			**Disadvantages.** Fusion process is time consuming, high dose of ionizing radiation, expensive.		

Table 2. cont

Authors	Imaging methods			Bite registration	Registration method
	Facial skeleton	Soft tissue	Dentition		
Uechi et al.[72]	CT	None	Laser scan of dental cast	Plaster dental cast	Point based with a splint with markers
Method description. Reconstruction of 3-D skull model based on presurgical CT scan. Creation of virtual dentition models at pre- and postsurgical intercuspal positions (based on 3-D surface scans of plaster dental cast). Three steps of intermodality registration are performed to obtain final fusion model.					
Advantages. 3-step registration provides precision, possibility of simulating orthognathic surgery in 3-dimensional space, good visualization of the interocclusal relationship.			**Disadvantages.** Fusion process is time consuming, high dose of ionizing radiation, expensive.		

Girod et al.[73]	CT	3-D laser scanning	None	None	Surface based
Method description. 3-D CT scans of bone structure are integrated with 3-D laser scan of soft tissue. Surgical changes in bone structure are mapped to the soft tissue model.					
Advantages. Good visualization of the interocclusal relationship.			**Disadvantages.** Fusion process is time consuming, high dose of ionizing radiation, expensive.		
Ayoub et al.[74]	CT	3-D photography	None	None	Surface based
Method description. The 3-D CT scan and the photo-realistic soft-tissue surfaces were registered for superimposition with Procrustes registration method. The registration errors were relatively big around the eyebrows, eyelids and cheeks. Simultaneous recording of the face and skull may reduce this error.					
Advantages. Accurate and realistic method.			**Disadvantages.** High dose of ionizing radiation, lack of detailed information about dentition.		
Groeve et al.[75]	CT	3-D photography	None	None	Surface based
Method description. Skin surface is extracted from CT scan by thresholding. 3-D photograph is registered with skin surface using 3-D surface matching algorithm.					
Advantages. Accurate and realistic method.			**Disadvantages.** High dose of ionizing radiation, lack of detailed information about dentition.		
Khambay et al.[11]	CT	3-D photography	None	None	Surface based
Method description. The 3-D image acquired with 3-D photography and CT images were registered for superimposition by 3 different methods: Procrustes superimposition using artificial landmarks, Procrustes analysis using anatomic landmarks, and partial Procrustes analysis using anatomic landmarks and then registration completion by HICP (a modified Iterative Closest Point algorithm) using a specified region of both images.					
Advantages. Accurate and realistic method.			**Disadvantages.** High dose of ionizing radiation, lack of detailed information about dentition.		
Olszewski et al.[76]	CT	MRI	3-D laser scan of dental cast	Plaster dental cast	
Method description. Simulation of bone and TMJ movements can be performed. Cephalometric analysis is used to determine the 3-D reference frame for planning bone movements.					
Advantages. Accurate and realistic method.			**Disadvantages.** High dose of ionizing radiation, lack of detailed information about dentition.		
Xin et al.[77]	CT	3-D Stereo-photogram-metry	None	None	
Method description. 3-D head model is created based on patient's CT scans. Genetic algorithm was used to impose the image obtained from 3-D stereo-grammetry procedure on the head model.					
Advantages. Accurate and realistic method.			**Disadvantages.** High dose of ionizing radiation, lack of detailed information about dentition.		

Table 2. cont

Authors	Imaging methods			Bite registration	Registration method
	Facial skeleton	Soft tissue	Dentition		
Swennen et al.[78]	CBCT	2D photo	CBCT scan of dental cast	Plaster dental cast	Voxel based
Method description. Triple Voxel-based rigid registration is used for "triple" cone-beam computed tomography (CBCT). The patient is scanned with a wax wafer (it keeps the correct position of head), then the patient with Triple Tray AlgiNot impression is scanned and then scan of the impression is done.					
Advantages. Lower dose of ionizing radiation. Accurate method for surgical planning.			**Disadvantages.** Time consuming, registration errors caused by differences in head positioning, Different facial expressions and artifacts during image acquisition.		

Barone et al.[79]	CBCT	Laser scanning (surface structured light scanning)	None	Plaster dental cast	Surface based
Method description. Laser scan of dental tissue and CBCT are fused to create multi-body orthodontic models.					
Advantages. Lower dose of ionizing radiation. Accurate and photorealistic digital representation of the face.			**Disadvantages.** Time consuming, registration errors caused by differences in head positioning, Different facial expressions and artifacts during image acquisition.		
Jayarante et al.[80]	CBCT	3-D Stereo-photogram-metry	None	None	Surface based
Method description. Each of two pods of cameras contains two monochromatic and one color camera. Triangulation algorithm is used to create a 3-D photo. Then CBCT is made and both 3-D images are automatically aligned by computer software. Using reference areas (periorbital and nasolabial region) the 3-D photo is registered on CBCT scan (at first manually, then automatically).					
Advantages. Accurate and realistic method, images, low dose of radiation.			**Disadvantages.** Time consuming, generates high cost, impractical in clinical use.		
Maal et al.[20]	CBCT	3-D photo	None	None	Surface based
Method description. Different modalities of 3-D surface-matching algorithm (Iterated closest point algorithm) were tested. The registration errors were relatively large at the lateral neck, mouth and around the eyes.					
Advantages. Lower dose of ionizing radiation. Accurate and photorealistic digital representation of the face.			Time consuming, registration errors caused by differences in head positioning, Different facial expressions and artifacts during image acquisition.		
Rangel et al.[38]	None	3-D photo	CT scan of impression	Dental impression	Surface based
Method description. Three digital data sets are integrated: a digital dental cast, a digital 3-D photograph of the patient with cheek retractors to expose teeth in occlusion, and a digital 3-D photograph of the patient with normal facial expression with the teeth in occlusion. Special iterated closest point algorithm is used to match these data sets and to place them in the correct anatomical position.					
Advantages. Accurate method of facial soft tissue reconstruction, possibility of objective evaluation and quantitative assessment of soft tissue changes after orthognathic surgery.			**Disadvantages.** Lack of information about facial skeleton.		

Conclusion

New 3-D surface acquisition methods and emerging software systems for data analysis are constantly being improved. Creating an accurate 3-D model of an individual patient presents new opportunities in dental, orthodontic, orthognathic and aesthetic fields. Due to the fact that many nia obrazu, a także długi czas jego pozyskiwania (ryzyko powstania artefaktów ruchowych) sprawia, że metoda ta jest niepraktyczna w przypadku regularnego jej zastosowanie w zakresie planowania zabiegów chirurgii plastycznej twarzy, a także w planowaniu leczenia ortodontycznego oraz ortognatycznego. Co więcej, dane dotyczące kości of these techniques are new there are limited data concerning norms and standards (normative data) related to anatomical structures. Among the reviewed methods image fusion models appear to be the most accurate and realistic tools for analysis documentation, treatment planning and followup in plastic, reconstructive, orthognathic surgery and orthodontic treatment. On the basis of these techniques, a realistic prediction model of soft and hard tissue changes can be created.

nie są wystarczająco dokładne, aby przeprowadzić rekonstrukcję szkieletu.59-61 Metody trójwymiarowej rekonstrukcji twarzy, o których mowa powyżej opierają się na podejściu obrazowym. Istnieją również metody wykorzystujące ideę bazującą na modelu.

2.11. Rekonstrukcja twarzy oparta na wzorcowym modelu

Omawiane techniki wykorzystują modele ludzkiej twarzy z pewnymi cechami charakterystycznymi, które mogą ulec deformacji w celu wyregulowania określonego kształtu I ekspresji twarzy. Większość tego rodzaju metod trójwymiarowego obrazowania twarzy opiera się na modelu twarzy typu CANDIDE – maska z parametrami, która zawiera 113 punkty oraz 184 trójkąty na ludzkiej twarzy.62

2.12. Modele fuzji obrazów

W ostatnim czasie odnotowano niezwykły rozwój technik bazujących na fuzji obrazów, które pozwoliłyby na uzyskanie dokładniejszej rekonstrukcji modelu głowy. Tego rodzaju podejście jest szczególnie wartościowe w dziedzinie ortodoncji i ortognatyki, ponieważ ułatwia ono dokładną analizę trzech istotnych komponentów twarzy pacjenta, które mogą ulec zmianie pod wpływem leczenia. Tego typu trójwymiarowy, fuzyjny model głowy jest rzeczywisty, dokładny, a także przedstawia realny związek pomiędzy twarzoczaszką, tkanką miękką a uzębieniem. Do połączenia danych trójwymiarowych wykorzystuje się różne metody łączenia danych, podobnie jak w przypadku rekonstrukcji ostatecznego trójwymiarowego modelu głowy, gdzie wykorzystuje się różne zestawy metod obrazowania. Możliwe modele łączenia obrazów przedstawiono w tabeli 2.4,11,20,27,29,,38,53,57,63-80

Wniosek

Nowe metody pozyskiwania powierzchni trójwymiarowych oraz opracowywane oprogramowania służące do analizy danych są ciągle ulepszane. Stworzenie dokładnego modelu 3D dla indywidualnego pacjenta daje nowe możliwości w dziedzinie stomatologii, ortodoncji, ortognatyki I es tetyki. Ponieważ wiele z tych technik to nowe techniki, dane dotyczące norm i standardów (dane normatywne) skupiające się na strukturach anatomicznych są bardzo ograniczone. Przegląd metod obrazowania pozwala na stwierdzenie, że modele pozyskane przy wykorzystaniu metody fuzji obrazów wydają się być najbardziej dokładnymi i realistycznymi narzędziami służącymi do analizy dokumentacji, planowania leczenia oraz kolejnych działań w zabiegach chirurgii plastycznej, rekonstrukcyjnej i ortognatycznej, a także w leczeniu ortodontycznym. Na podstawie opisanych w artykule technik można stworzyć realistyczny model predykcyjny zmian w zakresie tkanki miękkiej i tkanki twardej.

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ISSN: 0011-4553

Effect of addition of antimicrobial triclosan on selected properties of water-activated glass ionomer cement

Wpływ dodatku przeciwdrobnoustrojowego triklosanu na wybrane właściwości cementu szklano-jonomerowego aktywowanego wodą

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A B S T R A C T

Introduction. Failure of dental restorations is commonly associated with residual infected dentine underneath. Dental materials containing antimicrobials may overcome the problem of recurrent caries without jeopardizing their physicomechanical characteristics. Aim of the study. To evaluate hardness and diametral tensile strength (DTS) of a wateractivated glass ionomer (WAGIC) enriched with increasing mass concentration of triclosan (TRC) – the antimicrobial agent. Material and methods. TRC was added to the powder of WAGIC in weight concentrations of 0.5%, 1.0%, 1.5%, 2.0% served as experimental groups, and 0.0% as a control group, respectively. In each group two subgroups were defined to record Vickers hardness (HV0.3/15) and DTS after 1 and 24 hours of storage in distilled water. ShapiroWilk test of normality, parametric (Ftest or t test) or nonparametric (KruskalWallis test or MannWhitney test) were used for the purpose of statistical analysis (p = 0.05); the equality of variance was checked with Levene's test.

Streszczenie

Wprowadzenie. Uszkodzenia wypełnień dentysty cznych są powszechnie związane z aktyw no ścią próchnicową pozostawionych w zębinie bakterii. Stosowanie materiałów stomatologicznych zawierają cych dodatki przeciwdrobnoustrojowe, które nie wpływałyby negatywnie na ich właściwości wytrzymałościowe mogłoby pozwolić na rozwiązanie problemu powikłań związanych z próchnicą wtórną. Cel pracy. Celem badania była ocena twardości i wytrzymałości na rozciąganie średnicowe (DTS) szkłojonomeru aktywowanego wodą (WAGIC) wzbogaconego triklosanem (TRC). Materiał i metody. Próbki wykonane z WAGIC stanowiły grupę kontrolną (0,0% TRC). Grupy badane stanowiły serie próbek z dodatkiem TRC w stężeniach wag. 0,5%, 1,0%, 1,5% i 2,0%. W każdej z grup przygotowano dwie podgrupy dla oznaczenia twardości i DTS po 1 I 24 godz. przechowywania próbek w wodzie destylowanej. Testy normalności ShapiroWilka, parametryczny (test F lub t test) lub nieparametryczny (KruskalaWallisa Results. HV0.3/15 was significantly higher after 24 h than after 1 h. In both cases addition of 0.5 % of TRC caused significant decrease of hardness. DTS values were significantly higher after 24 h with addition of 0.5 % TRC, but generally it was slightly decreased in comparison to the control group. Conclusions. Except 0.5 % TRC, there was no negative influence of antimicrobial addition on HV0.3/15 and DTS, so TRC does not deteriorate strength of WAGIC. lub MannaWhitneya) zostały wykorzystane do analizy statystycznej (p = 0,05); równość wariancji badano testem Levena. Wyniki. Twardość próbek była znacząco wyższa po 24 godzinach niż po 1 godzinie. Dla próbek 0,5 % była niższa w obu przypadkach w porównaniu z grupą kontrolną 0,0 %. Podsumowanie. Za wyjątkiem grupy 0,5 %, nie odnotowano negatywnego wpływu dodatku TRC na HV0,3/15 i DTS. TRC nie zaburza wytrzymałości WAGIC.

KEYWORDS: glass-ionomer, triclosan, hardness, DTS

Introduction

Amalgam and composite restorative materials are not natural ones and have many drawbacks. An alternative should be both easy to use and apply without complex procedures. In all cases, it should provide a reliable seal for the lesion brought by the decay process. The material should be as natural as possible in order to allow a powerful and natural remineralization process to further restore the defect and minimize the necessary preparation.1 Clinical trends themselves ensure, following Goldberg, that there will continue a sustained reduction in the use of dental amalgams in clinical practice across the European Union.2,3 In Mount's opinion, favourable restorative dental material that can adhere to the tooth and help in further prevention of caries by continuous fluoride release is none other than Glass Ionomer Cement.4

It was Sorel who 161 years ago introduced zinc oxide-chloride cement and then phosphate cement – the first synthetic dental cement. After 3 years Rostanigs reported obtaining the "artificial bone". Today we can say it was only zinc-oxide-phosphate cement but the biomimetic concept in search for substitute materials imitating tooth tissues began to bloom. 142 years ago Fletcher introduced what he called "artificial dentine", which in fact was only a zinc-sulphate cement; however, 4 years later he applied the first biomaterial for direct restorations, imitating hard dental tissues, "artificial dentine, artificial enamel" – a silicate cement by Steenbok's recipe. 53 years ago Smith introduced zinc-polycarboxylic cement. A very important step in the development of restorative materials in the context of safety, minimal invasiveness and biomimetic idea evolution was the first selfadhesive cariostatic glass-polyalkenocarboxylic cement (GIC) biomaterial called ASPA, developed 55 years ago by a team of McLean, Wilson, Kent, Crisp at the Laboratory of the Government Chemist in London, as a material that gels and sets as the result of interaction of Al3+ and Ca2+ ions extracted of the basic glass powder, with COO- polyanions in water-soluble poly(acrylic acid). Taking into consideration the chemical composition of GICs, conventional (CGIC), semi- and anhydrous (WAGIC), metal-reinforced (MRGIC), visiblelight-activated (VLAGIC), resin-modified (RMGIC – dual and tri-cured DCRMGIC and TCRMGIC) ones and newly introduced glass carbomers – HAp enriched, poly(diethylosiloxane) modified GICs, can be distinguished.5-8

Dental caries is a public health problem and the most prevalent infectious disease found in the oral cavity in humans. It results in destruction of sensitive dental hard tissues caused by Grampositive microorganisms: Streptococcus oralis, Streptococcus mitis, Streptococcus sanguis, and mostly by Streptococcus mutans and Lactobacillus acidofilus.9-12 Dentinal caries occurs in different layers of the tooth, in which the outer layer is highly infected with bacteria, resulting in an impossibility of remineralization. Nevertheless, the inner layer is less frequently contaminated with bacteria and although bacteria may dissolve the mineralized tissue, the cross-banded ultra-structure of the collagen matrix is preserved. Accordingly, the dentine of this carious layer can be preserved and remineralized if these bacteria are removed or killed.13,14 Also, during the ART procedures, dental hand instruments alone do not remove carious dentine as effectively as rotary burs, which does not ensure total microorganisms removal, and cariogenic bacteria can survive remaining under GICs restorations. The carious process may progress in the course of time and cause failure of the restoration. This problem may be solved by the use of dental materials that inhibit bacterial growth and thus termed Interim Therapeutic Restoration (ITR).15-18

In an attempt to obtain restorative materials that could prevent marginal gaps colonization, materials capable of releasing fluoride and providing antimicrobial activity have been developed, such as glass ionomer cements (GIC), the so-called "compomers" (PMRC) and fluoridated ceramicpolymer composites (RC).19 There is no doubt that fluoride in drinking water and oral care products serve to protect the teeth and improve oral health at an individual and community level. Clinical data is not supportive of an cariostatic effect of GICs, and there is no clear evidence to support beneficial result of fluoride-releasing restorative materials.20 In 1988, Purton and Rodda showed that the cement not only releases fluoride ions, but that it also can release calcium, phosphate, silica, strontium and other ions from glass/bioglass.21-23

The ability of GICs to release F-, Ca2+, PO4, SiO44- ions and their cariostatic activity may have led to the hypothesis that these restorative materials would potentially be used as potential carrier systems/delivery matrix for antimicrobial agents (Amb).

The oldest recorded medical use of an antimicrobial agent concerned copper mentioned in the Smith Papyrus; this Egyptian medical text, written 4600-4400 years ago describes the application of copper to sterilize chest wounds and drinking water. Ancient Egyptians and ancient Greeks also used specific molds and plant extracts to treat infection.24,25 Looking back on the history of human diseases, infectious diseases have accounted for a very large proportion of diseases as a whole. Almost 150 years ago there was no knowledge that microorganisms were found to be responsible for a variety of infectious diseases that had been plaguing humanity from ancient days. Accordingly, chemotherapy aimed at the causative organisms was developed as the main therapeutic strategy. The first synthetic antimicrobial agent in the world was salvarsan, a remedy for syphilis that was synthesized by Ehrlich 106 years ago. 81 years ago sulfonamides were developed by Domagk and other researchers. These drugs were synthetic compounds and had limitations in terms of safety and efficacy. 88 years ago Fleming discovered penicillin.26

Among many antimicrobials incorporated into dental restorative material, organic ones were introduced into restorative dental materials, wellknown and tested e.g. bisbiquanides: chlorhexidine digluconate and diacetate (CHG, CHXA), alexedine (ALX), chitosane (CHT), monomers 12-methacryloyloxydodecylpyridinium bromide (MDPB), quaternary ammonium dimethacrylate (QADM), furanone chloride and bromide (GLC), polyquaternary ammonium salt (PQAS), cetrimide (CT), polyethyleneimine nanoparticles (nPEI), zinc oxide nanoparticle (nZO), cetylpyridinium chloride (CPC), glutaraldehyde (GA), benzalkonium chloride (BACH), sodium fusidate (SF), antibiotics (metronidazole, ciprofloxacin and cefaclor).27-37

There are only a few papers that deal with triclosan (TRC) as an addition into dental restoratives. Triclosan is a chlorinated aromatic compound (in use since 1972) [5-chloro-2-(-2, 4-dichlorophenoxyl) phenol] with summary formula C12H7Cl3O2 and molar mass of 289.54 g/ mol-1, synthetic white powdered species, nonionic, broad spectrum antimicrobial and antifungal agent, anionic by nature. The proposed mechanism of action of triclosan suggests the material to be bactericide/also fungi RNA immobilizer, which does not leach from the carrier material, thereby favouring long-term anticariogenic activity. It is slightly soluble in water and very soluble in ethanol, methanol, diethyl ether and very well soluble in basic solutions, e.g. sodium hydroxide.38-41 Triclosan is present in soaps (0.10-1.00%), deodorants, toothpastes 0.3%, mouthrinses 0.15% and cleaning materials. It is incorporated into an increasing number of consumer products, such as kitchen utensils, toys, bedding,

socks, and rubbish bags.42 At high concentrations triclosan acts as a biocide, with multiple cytoplasmic and membrane targets. At lower concentrations, however, triclosan appears bacteriostatic and is seen to target bacteria mainly by inhibiting fatty acid synthesis. It demonstrates effective antimicrobial action when added to GICs.43 TRC does not deteriorate shear bond strength (SBS) and the marginal seal of GICs in dye penetration test, as is further explained. It is important to notice this higher shear bond strength values for triclosan-incorporated glass ionomer cement group than for conventional glass ionomer cement group. Microleakage of 2.5% triclosan-incorporated GIC was compared with conventional type II GIC and the results revealed that microleakage was similar to that of conventional GIC.44,45

The idea is to enhance the antimicrobial properties of GICs with a balanced dose of additives incorporated into the compound, without causing biological, physical and chemical changes of a biomaterial. It is suggested that these restorative materials can be used as controlledrelease devices, a topic of great interest in modern day pharmacy.46 Taking it into consideration, the project was started with evaluating surface hardness (HV0.3/15) and diametral tensile strength (DTS) of a water-activated glass ionomer cement (WAGIC) enriched with increasing mass concentration of triclosan (TRC) antimicrobial.

Material and methods

Samples preparation

Triclosan (5-chlor-2-(2,4-dichlor-phenoxy)phenol, Merck, Germany) was added to the powder of WAGIC (Chemfill Superior, Dentsply DeTrey, Germany) in weight concentrations of 0.5%, 1.0%, 1.5%, 2.0% serving as experimental groups, and 0.0% as a control group. Then, according to manufacturer's instructions, water was added to TRC and WAGIC mixture and mixed to material homogenization. The obtained paste was placed into silicon mould to prepare samples for DTS and HV0.3/15 test and then left in distilled water for 1 or 24 hours.

Hardness

After predetermined time (1 or 24 hours) hardness measurements were performed using hardness tester (ZHμ, Zwick/Roell, Germany).

To evaluate samples' hardness, the Vickers test was used. In this test 136° diamond square-based pyramid was used as an indenter. Indenter was pressed into the material's surface using load of 300 g. After 15 s the load was removed and diagonal lengths of the indentation were measured. Vickers hardness was calculated from equation (1) as follows:

$$HV = const.\frac{F}{A} = 0{,}102\,\frac{2F\sin\frac{136^\circ}{2}}{\left(\frac{d_1+d_2}{2}\right)^2} = 0{,}1819\frac{F}{d^2} \quad (1)$$

where:
F – load force [N],
A – surface of the indentation [μm^2],
d_1, d_2 – diagonal lengths [μm].
Each impression point was made in at minimum 3 diagonal lengths distance. On each sample 7 impression points were made in different places. Results were subjected to statistical analysis.

Diametral tensile strength

Diametral tensile strength (DTS) test was performed according to ANSI/ADA standard No. 66. after 1 or 24 hours of storing samples in distilled water. The DTS method is presented schematically in Fig. 1.

In this test, a compression load was placed by peripheral surface of a cylindrical sample (diameter d = 6 mm, height h = 3 mm). In a perpendicular direction to the applied force direction, the tensile forces occurred. In this test, the maximum force was measured by universal testing machine (Z020, Zwick/Roell, Germany) with crosshead speed 0.5 mm/min. The DTS value was calculated with the following equation (2):

$$DTS\ [MPa] = \frac{F}{S}\frac{[N]}{[mm^2]} = \frac{F}{\frac{1}{2}\left(2\pi\frac{d}{2}h\right)}\frac{[N]}{[mm \cdot mm]} = \frac{2F}{\pi d h}\frac{[N]}{[mm^2]} \quad (2)$$

where:
DTS – diametral tensile strength [MPa],
F – maximum force [N],
S – surface [mm^2],
d – sample diameter [mm],
h – sample height [mm].
Results were subjected to statistical analysis.

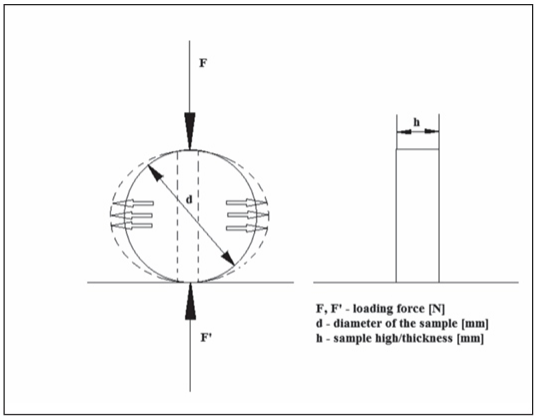

Fig. 1. *DTS testing method scheme.*

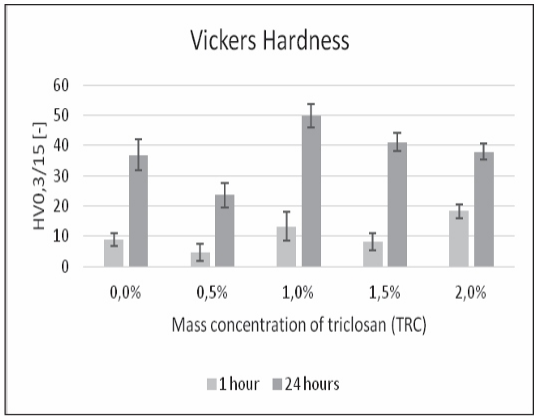

Fig. 2. *Vickers hardness results for WAGIC modified with TRC.*

Statistical analysis

For statistical calculations Excel 2010 (Microsoft, USA) and Statistica v. 12.5 (Statsoft, Poland) were used. Shapiro-Wilk Test of normality, parametric (F-test or t-test) or non-parametric (Kruskal-Wallis test or Mann-Whitney test) tests were used for the purpose of the statistical analysis (alpha = 0.05). Equality of variance was tested with Levene's test.

Results

Hardness

HV0.3/15 results for specimens with different concentration of TRC stored for 1 or 24 hours in distilled water in room temperature are shown in Fig. 2.

According to Kruskal-Wallis test there were statistically significant differences in HV0.3/15 measured after 1 hour between samples with 0.0% and 2.0% (p-value=0.046), 0.5% and 1.0% (p-value=0.005), 0.5% and 2.0% (p-value=0.000), 1.5% and 2.0% (p-value=0.015) concentration of triclosan. According to the F-test, there were statistically significant differences in HV0.3/15 measured after 24 hours between the following concentrations of TRC in samples: 0% and 0.5% (p-value=0.003), 0% and 1% (p-value=0.004), 0.5% and 1% (p-value=0.000), 0.5% and 1.5% (p-value=0.000), 0.5% and 2% (p-value=0.001), 1% and 2% (p-value=0.010). As shown in Fig. 2 the samples' hardness measured after 24 hours of storage in wet condition was statistically higher than in samples tested after 1 hour.

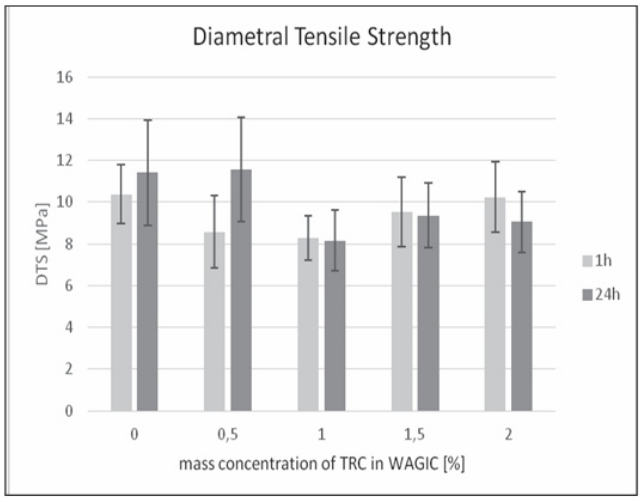

Fig. 3. *DTS results for WAGIC modified with TRC.*

Diametral Tensile Strength

Diametral tensile strength results for samples with mass concentration of TRC from 0.0% to 2.0% measured after 1 or 24 hours of storage in distilled water are shown in Fig. 3.

The DTS values measured after storing samples for 1 hour in distilled water was statistically lower for 1.0% addition of TRC compared to samples with 0.0% (p-value=0.019) and 2.0% (p-value=0.033). DTS values measured after 24 hours was slightly higher for 0.0% (p-value=0.009) and 0.5% (p-value=0.006) in comparison with DTS samples with 1.0% TRC addition. There were no statistically significant differences between DTS values measured after 1 and 24 hours, except 0.5% TRC addition to WAGIC. In these samples, after 24 hours of storage in water DTS was higher than after 1 hour (p-value=0.012).

Discussion

The perfect restorative filling material would be the one that can degrade in the mouth and be replaced by natural tooth enamel and dentine. Such an ideal material does not yet exist.8 This concept is probably the nearest to GICs releasing different species. Also, it can be expected that glass-ionomer-like formulations will play the prominent role in the concept of biomimesis, the exploration of biomaterials that repair or reproduce the original tissues best47 over maturation times greater than 24 hours.48 Glass-ionomer cements are considered to be anti-cariogenic. One of the key features that promotes this property is their ability to release fluoride, but it is also aided by their ability to buffer

organic acids, such as lactic acid.49-51 In the past decade, antimicrobial agents have been incorporated into dental materials to provide them with antimicrobial activity. Many AMb have been used, but they affected the various physical properties of the material at different concentrations.52,53 Sainulabdeen et al.43 studied the antibacterial effect of triclosanincorporated glass ionomer cement and concluded that 2.5% concentration of triclosan-incorporated GIC produces optimum antibacterial effect in comparison with 2.5% chlorhexidine.

The incorporation of AMb (e.g. chlorhexidine acetate and gluconate) to glass ionomer cement may result in a dramatic decrease in the physicomechanical properties of the cement; when added in concentrations above 5.0%, the material tends to deteriorate rapidly, does not contribute to the formation of glass ionomer network, weakens the scaffold, and compromises the mechanical properties of glass ionomer cement.54,55 Bearing this in mind, it was decided to test lower mass concentration of TRC.

Cationic species like QAS-containing materials did exhibit significant antibacterial activities. However, it has been reported56 that human saliva can significantly decrease the antibacterial activity of the QAS-containing restoratives, probably due to electrostatic interactions between QAS and proteins in saliva, as cationic species. Choosing anionic TRC, anionic chemical, would be of interest for long-term action in slow-controlled release.

In the present study, samples hardness was confirmed to be significantly higher after 24 hour than after 1h of storage in distilled water, a wellknown GICs property, also obtained for GICs with TRC addition by Pawluk in PhD thesis.57 Addition of 0.5% of TRC caused significant decrease of hardness. DTS values were significantly higher after 24 h with addition of 0.5%, but generally it was slightly decreased in comparison with the control group, that corresponds with Tüzüner et al.; antimicrobial agents like CPC, CT, BACH when incorporated into glass ionomer cement affected the clinical performance of the material as they reduced the compressive strength, surface hardness, bond strength but slightly increased the setting time.58 Opposite DTS data were obtained by the team of Jaidka et al. for 0.5% TRC-enriched GIC.59 A possible reason for those discrepancies might be assigned to the different dimensions of the sample.

The prevalence of caries and the increase in drug resistance in the pathogenic bacteria and fungi at an alarming rate is a matter of serious concern. Therefore, there is a pressing demand to discover novel strategies and identify new antimicrobial agents from natural and inorganic substances to develop the next generation of drugs or agents to control microbial infections. There are several future aspects of using AMb-enriched GICs in clinic, when planning investigations, where indications/contraindications, dose, and oral/ general safety/hazard may play an important role.

As Noort mentioned, there is a subtle distinction between safety and biocompatibility – two important features of dental materials. Safety is concerned with the fact that materials when in contact with the human body should not cause any adverse effect, whereas biocompatibility is the quality of being non-destructive in the biological environment maintaining the beneficial effect to the patient. So far, few materials can be regarded as completely safe and fully biocompatible in the oral environment. Most dental materials interact with the oral environment and this interaction might involve a release of components with undesirable side effects for oral tissues.60 From that perspective, it can be stated that two main approaches can be presented when antimicrobial bioactive materials are prepared. One

approach is to prepare a substance-release material. Another perspective is to incorporate the antimicrobial to be active being part of its structure without any release of the active component.61 The proposed mechanism of action of TRC suggests the material to be an immobilized bactericide which does not leach out of the carrier material, thereby favouring long-term anticariogenic activity.62

Conclusion

Except addition of 0.5% TRC into WAGIC, there was no negative influence of antimicrobial addition on HV0.3/15, and DTS values were slightly decreased, so TRC does not deteriorate mechanical properties of WAGIC.

The improvement of anticariogenic properties of a biomimetic direct dental restorative is of great importance, as it would lead to the reduction of probability of reinfection of restored tooth hard tissues, and would prevent the formation of secondary caries.

It is also recommended that further aspects of TRC-incorporated glass ionomer cement should also be researched before recommending it as an effective antimicrobial alternative to conventional glass ionomer cement.

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ISSN: 0011-4553

Surgical and prosthetic treatment of a patient with Wegener's granulomatosis

Postępowanie chirurgiczno-protetyczne w przypadku pacjentki obciążonej ziarniniakiem Wegenera

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ABSTRACT

Wegener's granulomatosis is an uncommon systemic disease that belongs to the group of necrotizing granulomatous vasculitides. The disease generally involves the upper and lower respiratory tract and kidneys. In the oral cavity it is manifested by hyperplastic granular gingivitis called "strawberry gingivitis". This article presents a female patient who suffered from Wegener's granulomatosis with indications for surgical and prosthetic treatment. At the time of the first visit, the clinical examination revealed missing teeth replaced with fixed prostheses, teeth denudation and mobility. After analyzing the clinical status and orthopantomograph, it was decided to extract all maxillary teeth and fabricate immediate complete upper denture. Follow-up appointments showed prolonged healing with significant and uneven loss of bone tissue. Despite this the patient adapted quite well to the prosthesis. After three weeks, Mollosil (Detax, Germany) soft relining material was applied, which was then replaced with acrylic one. After stabilization of the prosthetic surface, construction of a new upper denture is planned.

Streszczenie

Ziarniniak Wegenera jest rzadkim schorzeniem układowym należącym do grupy martwiczych, ziarniniakowych zapaleń naczyń krwionośnych. Choroba dotyczy głównie naczyń górnych i dolnych dróg oddechowych oraz nerek. W obrębie jamy ustnej zmiany występują w postaci przerostu dziąseł, które przybierają wygląd truskawki. W pracy opisano przypadek pacjentki ze zdiagnozowanym ziarniniakiem Wegenera i wskazaniami do leczenia chirurgiczno-protetycznego. W momencie zgłoszenia się pacjentki do leczenia protetycznego w badaniu klinicznym stwierdzono braki zębowe uzupełnione z zastosowaniem protez stałych oraz znacznie obnażone i rozchwiane zęby. Po analizie stanu klinicznego i zdjęcia pantomograficznego podjęto decyzję o ekstrakcji wszystkich zębów szczęki i wykonaniu natychmiastowej protezy całkowitej górnej. Obserwowano przedłużone gojenie ze znacznym i nierównomiernym zanikiem tkanki kostnej. Pomimo to chora dość dobrze zaadaptowała się do użytkowanej protezy. Po 3 tygodniach wykonano miękkie podścielenie protezy materiałem Mollosil (Detax, Niemcy), który następnie wymieniono na akryl. Po ustabilizowaniu się podłoża protetycznego planowane jest wykonanie nowej protezy całkowitej górnej.

KEYWORDS:
Wegener's granuloma, granulomatosis with polyangitis, strawberry hyperplastic gingivitis

Introduction

Wegener's granulomatosis is an autoimmune systemic disease. The characteristic features of this disease include necrotizing inflammation of small and medium-sized blood vessels involving many organs. In its classical form, the disease has a predilection to the upper and lower respiratory tract, blood and kidneys. Another characteristic feature is the formation of granulomas, and the presence of antineutrophil cytoplasmic antibodies (ANCA).1-10 As the result of the hypersensitivity reaction, directed against inhaled infectious or environmental antigens, autoantibodies and immune complexes, accumulated in the vessel walls with a small diameter, are produced. It leads to inflammation, thrombotic lesions, reduction of perfusion and necrosis.4 There are two forms of the disease: limited and generalized. In the first one, there is no evidence of severe damage to vital organs, while in the latter one, there is a considerable organ damage leading to the death of the patient.[2] Some authors consider the limited form to be the early stage of generalized Wegener's granulomatosis.7

The diagnosis is determined on the basis of characteristic clinical features, outcome of histopathological examination, and determination of antineutrophil cytoplasmic antibody titers. Wegener's granulomatosis occurs most frequently in the fourth decade of life. In the initial period, it gives non-specific symptoms. Usually there is weakness, lack of appetite and associated weight loss. In over 70% of patients, the first signs concern the upper respiratory tract, among them, ulceration of the nasal ducts, nasopharyngitis with the presence of purulent or sanguinopurulent discharge.3,10 Sinusitis is diagnosed in approximately 90% of patients.6 Changes in the lungs occur in 74% of patients and manifestations include cough, hemoptysis, shortness of breath and discomfort in the chest.6 On chest radiographs, nodular thickenings or infiltrates of 1-9 cm in diameter are visible.3 Renal lesions, initially asymptomatic, can gradually lead to glomerulonephritis. Approximately 50% of patients are likely to develop ophthalmic symptoms primarily as scleritis or corneal ulcers.6

Wstęp

Ziarniniak Wegenera jest chorobą układową o podłożu autoimmunologicznym. Schorzenie to charakteryzuje się martwiczym zapaleniem małych i średnich naczyń krwionośnych obejmującym wiele narządów. W klasycznej postaci choroby dotyczy głównie górnych i dolnych dróg oddechowych, naczyń oraz nerek. Cechą charakterystyczną jest powstawanie ziarniniaków I obecność przeciwciał przeciwko cytoplazmie granulocytów obojętnochłonnych (ANCA).1-10 W wyniku reakcji typu nadwrażliwości komórkowej, skierowanej przeciwko wdychanym antygenom zakaźnym lub środowiskowym dochodzi do wytworzenia autoprzeciwciał, a następnie kompleksów immunologicznych odkładających się w ścianach naczyń o małej średnicy, co prowadzi do ich stanu zapalnego, zmian zakrzepowych, zmniejszenia perfuzji I martwicy.4 Wyróżnia się dwie postaci choroby: ograniczoną i uogólnioną. W pierwszej nie stwierdza się ciężkiego uszkodzenia ważnych narządów, natomiast w drugiej dochodzi do znacznych uszkodzeń narządów, prowadzących do zgonu chorego.2 Postać ograniczona uważana jest przez niektórych autorów za wcześniejsze stadium uogólnionej.7

Rozpoznanie choroby ustala się na podstawie charakterystycznego obrazu klinicznego, wyniku badania histopatologicznego, oznaczeniu miana przeciwciał przeciwko składnikom cytoplazmy granulocytów obojętnochłonnych.5

Ziarniniakowatość Wegenera pojawia się najczęściej w czwartej dekadzie życia. W początkowym okresie daje niespecyficzne objawy. Zwykle jest to osłabienie, brak apetytu i związana z tym utrata masy ciała. U ponad 70% chorych pierwsze objawy pojawiają się w obrębie górnych dróg oddechowych, są to: owrzodzenia przewodów nosowych, jamy nosowo-gardłowej z obecnością ropnej lub krwisto-ropnej wydzieliny.3 Zapalenie zatok obocznych nosa stwierdza się u około 90% pacjentów.6 Zmiany w obrębie płuc występują u 74% chorych I objawiają się kaszlem, krwiopluciem, dusznością, dyskomfortem w obrębie klatki piersiowej.6 Na zdjęciach radiologicznych klatki piersiowej widoczne są guzkowate zagęszczenia lub nacieki o średnicy 1-9 cm.3 Zmiany w nerkach stopniowo z postaci bezobjawowej mogą doprowadzić do kłęThe disease demonstrates a characteristic image in the oral cavity manifested with the enlargement of the gingivae, which are swollen, grainy and dark red, resembling a ripe strawberry. Initially, hypertrophy refers only to interdental papillae, but gradually covers the labial and buccal surfaces of the gingivae. According to some authors, these changes occur a few weeks or months before the involvement of visceral organs.1,8,9 After the exclusion of other potential causes of gingival overgrowth (drug response, leukaemia, hormonal disorders), it is advisable to perform a histopathological examination of the fragment of the affected tissue and the presence of ANCA in the serum. Histopathological examination rarely corresponds to the changes in the lungs or kidneys, so further careful observation of the patient is recommended. Another important symptom of the disease is ulcers of the oral mucosa, often coexisting with ulcerated throat. These lesions are painful. Fistulas between the oral cavity and paranasal sinuses, facial hypoesthesia, dysgeusia are uncommon. A histopathological examination of ulcers and determining the level of ANCA in the serum is necessary. Post-extraction wound healing is inadequate. Adaptiation to removable dentures is unsatisfactory.1,8

The aim of the study was to present a rehabilitation of the patient with a systemic disease – Wegener's granulomatosis.

Case report

A 78-year-old patient presented for prosthetic treatment. The main complaint was the aesthetics and mobility of the teeth in the maxilla (Fig. 1-3). In 2002, the patient was diagnosed with granulomatosis vasculitis (Wegener's granuloma), which began with acute pneumonia. The chest X-ray revealed granulomatous lesions in the lungs. Pathological symptoms in the oral cavity appeared a few years later as swelling and redness of the gingiva. In subsequent years, there occurred granular hyperplasia of the gingiva manifesting as "strawberry gingivitis". The patient received proper periodontal treatment, as a result of which the gingival overgrowth resolved. On the other hand, extensive bone loss became apparent. buszkowego zapalenia nerek. U około 50% chorych dochodzi do wystąpienia objawów ocznych w postaci zaplenia twardówki, owrzodzenia rogówki.6

Choroba przybiera charakterystyczny obraz w obrębie jamy ustnej. Manifestuje się przerostem dziąseł, które są rozpulchnione, ziarniste, rumieniowo-czerwone przypominające wyglądem dojrzałą truskawkę. Przerost dotyczy początkowo brodawek międzyzębowych, stopniowo obejmuje powierzchnię wargową i policzkową dziąseł. Według części autorów zmiany te występują nakilka tygodni lub miesięcy przed pojawieniem się zmian narządowych.1,8,9 Po uwzględnieniu innych potencjalnych przyczyn przerostu dziąseł (zmiany polekowe, w przebiegu białaczki, zaburzenia hormonalne) wskazane jest pobranie fragmentu zmienionej tkanki celem badania histopatologicznego oraz zbadania przeciwciał ANCA w surowicy. Wynik badania histopatologicznego rzadko odpowiada

zmianom obecnym w płucach czy nerkach, a więc wskazana jest dalsza wnikliwa obserwacja chorego. Kolejnym ważnym objawem choroby są owrzodzenia błony śluzowej jamy ustnej, często współistniejące z owrzodzeniami gardła. Zmiany te są bolesne. Rzadko spotyka się przetoki pomiędzy jamą ustną a zatokami obocznymi nosa, niedoczulicę skóry twarzy, zaburzenia smaku. Konieczne jest badanie histopatologiczne owrzodzeń wraz z określeniem poziomu przeciwciał ANCA w surowicy. U chorych występuje utrudnione gojenie ran poekstrakcyjnych. Adaptacja do wykonanych ruchomych uzupełnień protetycznych jest niesatysfakcjonująca.1,8 Celem pracy było przedstawienie postępowania rehabilitacyjnego u pacjentki obciążonej chorobą ogólnoustrojową – ziarniniakiem Wegenera.

Opis przypadku

Pacjentka w wieku 78 lat zgłosiła się w celu zaplanowania leczenia protetycznego. Problemem chorej był wygląd estetyczny oraz ruchomość zębów w szczęce (Fig. 1-3). W 2002 roku zdiagnozowana została ziarniniakowatość z zapaleniem naczyń (ziarniniak Wegnera), która rozpoczęła się ostrym zapaleniem płuc. Na zdjęciu rtg klatki piersiowej uwidoczniono zmiany ziarniniakowe w płucach. Zmiany w jamie ustnej pojawiły się

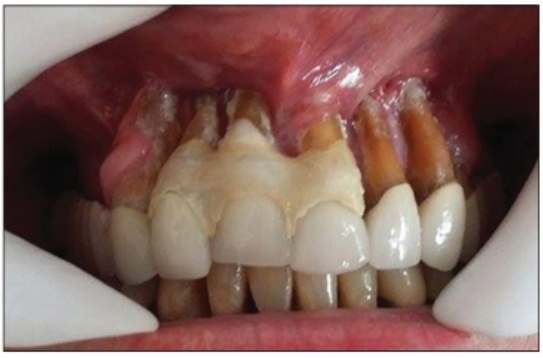

Fig. 1. *Intraoral view – the clinical condition before prosthetic treatment.*
Zdj. wewnątrzustne – stan kliniczny jamy ustnej pacjentki w momencie zgłoszenia się do leczenia protetycznego.

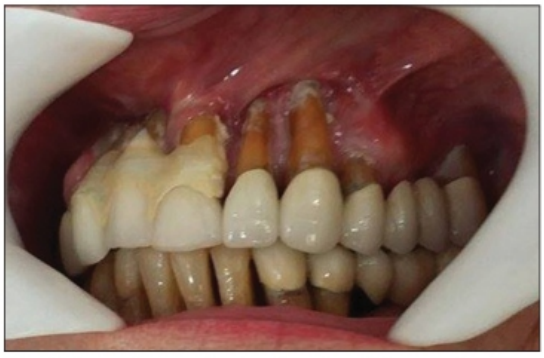

Fig. 2. *Intraoral view – the clinical condition before prosthetic treatment.*
Zdj. wewnątrzustne – stan kliniczny jamy ustnej pacjentki w momencie zgłoszenia się do leczenia protetycznego.

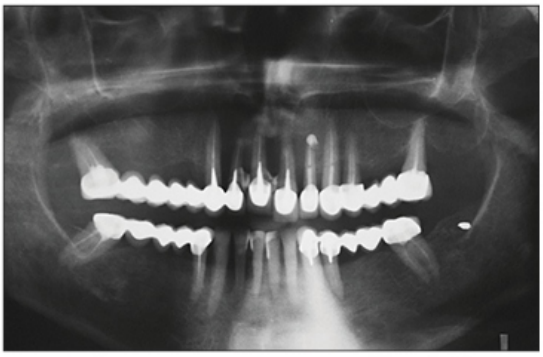

Fig. 3. *Orthopantomogram – extensive maxillary alveolar process bone loss.*
Zdj. pantomograficzne – rozległy zanik tkanki kostnej wyrostka zębodołowego szczęki.

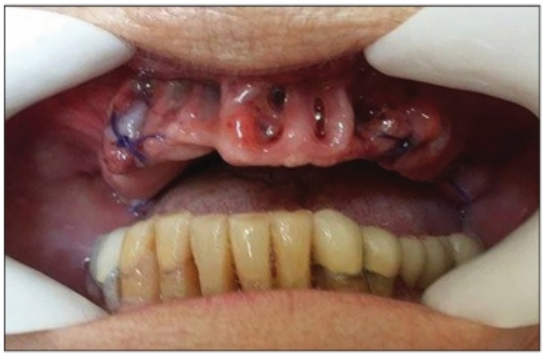

Fig. 4. *Intraoral view – clinical condition after extractions in the maxilla. The alveoli are sutured.*
Zdj. wewnątrzustne – stan po usunięciu zębów szczęki. Zębodoły poekstrakcyjne zaopatrzone szwami chirurgicznymi.

There was considerable exposure of the roots and pathological mobility of the teeth. At the time of the first visit, clinical examination revealed missing teeth replaced with the use of fixed prostheses, teeth denudation and mobility (Fig. 1-3).

After analyzing the clinical status and an orthopantomograph (Fig. 4), it was decided to extract all maxillary teeth and fabricate immediate complete upper denture. Bite registration, upper and lower alginate impressions were taken. After removal of the bridges in the Department of Cranio-Maxillofacial Surgery, Oral Surgery and Implantology teeth 17, 13, 12, 11, 21, 22, 23, 24, 27 were extracted. Prior to the surgery, an antibiotic in the form of two tablets of 625 mg of amoxicillin with clavulanic acid were administered and it kilka lat później w postaci obrzęku I zaczerwienienia dziąseł. W kolejnych latach doszło do truskawkowatego przyrostu dziąseł. Pacjentka została poddana leczeniu periodontologicznemu, w wyniku którego ustąpiły przerosty dziąseł, uwidocznił się natomiast rozległy zanik kości. Doszło do znacznego obnażenia korzeni I ruchomości patologicznej zębów. W momencie zgłoszenia się pacjentki do leczenia protetycznego w badaniu klinicznym stwierdzono braki zębowe uzupełnione z zastosowaniem protez stałych oraz znacznie obnażone i rozchwiane zęby (Fig. 1-3).

Po analizie stanu klinicznego i zdjęcia pantomograficznego (Fig. 4) podjęto decyzję o ekstrakcji wszystkich zębów szczęki i wykonaniu natychmiastowej protezy całkowitej górnej. Pobrano

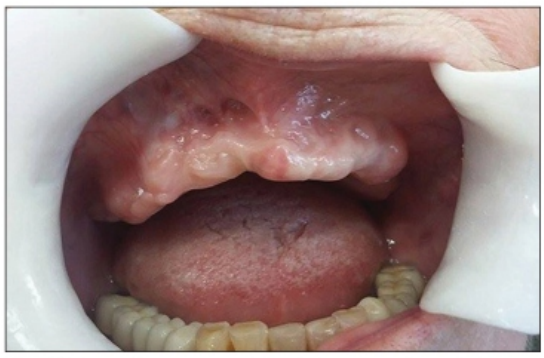

Fig. 5. *Intraoral view – uneven loss of bone tissue during healing.*
Zdj. wewnątrzustne – nierównomierny zanik tkanki kostnej w trakcie gojenia.

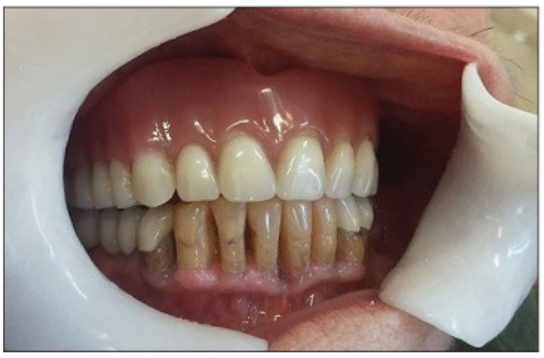

Fig. 6. *Intraoral view – clinical condtion after treatment. Immediate complete upper prosthesis.*
Zdj. wewnątrzustne – stan po leczeniu, proteza natychmiastowa całkowita górna.

was recommended that the antibiotic therapy be continued with one tablet of 625 mg every 12 hours for 7 days. The wounds were secured with surgical sutures; haemostasis was achieved (Fig. 5). After the procedure, the patient's immediate prosthesis was inserted. Follow-up appointments showed prolonged healing with significant and uneven loss of bone tissue (Fig. 6). The patient adapted quite well to the prosthesis. After three weeks, Mollosil (Detax, Germany) soft relining material was applied, which was then replaced with acrylic one. After stabilization of the prosthetic surface, construction of a new upper denture is planned.

Conclusion

Individuals with Wegener's granuloma form a small group of patients. Dental treatment is complex, and satisfactory results of prosthetic treatment are not always achievable. In this case, the only proper solution was the extraction of maxillary teeth and prosthetic restoration with an immediate denture.

Impaired healing and initial discomfort during the use of the prosthesis significantly improved after lining. Further treatment plan for the patient includes construction of a new upper denture and regular dental checkup of the teeth in the lower arch. It should be noted that, in the described case, oral lesions appeared a few years after the diagnosis of the disease; however, as described by many authors, they rejestrat zwarcia oraz górny i dolny wycisk alginatowy. Po zdjęciu mostów uzupełniających braki zębowe w odcinkach bocznych górnego łuku zębowego w Ambulatorium Kliniki Chirurgii Czaszkowo-Szczękowo-Twarzowej, Chirurgii Jamy Ustnej i Implantologii usunięto zęby – 17, 13, 12, 11, 21, 22, 23, 24, 27. Chora przed zabiegiem mnogich ekstrakcji otrzymała antybiotyk Augmentin w postaci 2 tabletek 625 mg, a następnie zalecono kontynuację antybiotykoterapii w dawce 1 tabletka 625 mg co 12 godzin przez 7 dni. Rany zaopatrzono szwami chirurgicznymi, uzyskano hemostazę (Fig. 5). Bezpośrednio po zabiegu do jamy ustnej pacjentki wprowadzono protezę natychmiastową. Na wyznaczonych wizytach kontrolnych obserwowano przedłużone gojenie ze znacznym i nierównomiernym zanikiem tkanki kostnej (Fig. 6). Chora dość dobrze zaadaptowała się do użytkowanej protezy. Po 3 tygodniach wykonano miękkie podścielenie protezy materiałem Mollosil (Detax, Niemcy), który następnie wymieniono na akryl. Po ustabilizowaniu się podłoża protetycznego planowane jest wykonanie nowej protezy całkowitej górnej.

Podsumowanie

Chorzy z ziarniniakiem Wegenera stanowią nieliczną grupę pacjentów. Postępowanie stomatologiczne jest skomplikowane i nie zawsze uzyskuje się satysfakcjonujące wyniki leczenia protetyczoften precede systemic symptoms of Wegener's granulomatosis.1,8,9 Thorough dental examination, as an introduction to interdisciplinary treatment, may help in the early diagnosis of granulomatosis with polyangitis.

nego. W przedstawionym przypadku jedynym prawidłowym postępowaniem ze względu na stan zębów w szczęce była ich ekstrakcja I uzupełnienie braków z zastosowaniem protezy natychmiastowej. Utrudnione gojenie i początkowy dyskomfort podczas użytkowania protezy uległ znacznej poprawie po jej podścieleniu. Dalszy plan leczenia pacjentki obejmuje wykonanie nowej protezy całkowitej górnej oraz kontrolę stanu uzębienia w żuchwie. Należy zaznaczyć, że w opisanym przypadku zmiany w jamie ustnej pojawiły się kilka lat po zdiagnozowaniu choroby, jednak jak opisuje wielu autorów, często poprzedzają one objawy ogólnoustrojowe ziarniniaka Wegenera.1,8,9 Dokładne badanie stomatologiczne podmiotowe i przedmiotowe, jako wstęp leczenia interdyscyplinarnego może pomóc we wczesnej diagnozie ziarniniakowatości z zapaleniem naczyń.

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