MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
SUMY STATE UNIVERSITY
ACADEMIC AND RESEARCH MEDICAL INSTITUTE

Eastern Ukrainian Medical Journal

116, Kharkivska st., Sumy 40007, Ukraine eumj.med.sumdu.edu.ua
e-mail: eumj@med.sumdu.edu.ua ISSN: 2663-5909 (print)/2664-4231 (online)

How to cite / Як цитувати статтю: Poliukhovych Yu, Demkovych A, Bondarenko Yu. Characteristics of thermoplastic polymer denture base materials for prosthodontic constructions. *East Ukr Med J*. 2024;12(3): 466-475

DOI: https://doi.org/10.21272/eumj.2024;12(3): 466-475

ABSTRACT

Yuliia I. Poliukhovych
https://orcid.org/0009-0007-4726-9372
Orthopedic Dentistry Department,
I. Horbachevsky Ternopil National Medical University, Ternopil, Ukraine

Andrii Ye. Demkovych
https://orcid.org/0000-0001-9823-4283
Orthopedic Dentistry Department,
I. Horbachevsky Ternopil National Medical University, Ternopil, Ukraine

Yurii I. Bondarenko
https://orcid.org/0000-0003-2681-5526
Pathophysiology Department,
I. Horbachevsky Ternopil National Medical University, Ternopil, Ukraine

CHARACTERISTICS OF THERMOPLASTIC POLYMER DENTURE BASE MATERIALS FOR PROSTHODONTIC CONSTRUCTIONS

Introduction. In dentistry, there is a wide range of thermoplastic polymers for the removable constructions of dental prostheses, which are extremely promising in modern dental practice. Successful prosthetics of patients will depend on the properties of the selected structural materials.. Purpose of the study was to summarize current information, based on a review of literary sources, on the use of thermoplastic base materials for the manufacture of removable prostheses and improves the effectiveness of orthopedic treatment of patients with complete or partial absence of teeth.

Methods. A literature review was conducted using PubMed, Web of Science, SCOPUS, Google Scholar up to January 2024. There was no restriction on the date of publication or language. Searches using the MeSH (Medical Subject Headings) terms were conducted using synonyms and combinations of the following search terms: "removable prosthetics", "dental base materials", "thermoplastics" "materials science", and "adaptation". Used methods: bibliographic and analytical.

Results. Thermoplastic materials are characterized by bioinertness for the organism, because they do not contain residual monomer. The technology of injection molding of thermoplastic polymers is considered as a promising technology in modern dentistry to achieve high aesthetic standards. The general characteristic of this group of materials is the absence of residual monomer and, accordingly, their biological indifference, a high level of plasticity, precision during the manufacture of the prosthesis, and a wide range of colours.

Conclusion. Polymer denture base plastics do not have optimal physico-mechanical, biological and surface characteristics, so the search for new materials for the manufacture of removable prostheses remains a promising direction.

Key words: removable prosthetics, dental base materials, thermoplastics, mucous membrane, materials science, nylon prosthesis, acetate prosthesis, acrylic prosthesis, prosthetic dentistry, adaptation.

Corresponding author: *Andrii Demkovych, I. Horbachevsky Ternopil National Medical University, 1 Maidan Voli, Ternopil, 46001, Ukraine*
e-mail: demkovushae@tdmu.edu.ua
+380979342501

РЕЗЮМЕ

Юлія І. Полюхович
https://orcid.org/0009-0007-4726-9372
Кафедра ортопедичної стоматології, Тернопільський національний медичний університет імені І.Я. Горбачевського МОЗ України, м. Тернопіль, Україна

Андрій Є. Демкович
https://orcid.org/0000-0001-9823-4283
Кафедра ортопедичної стоматології, Тернопільський національний медичний університет імені І.Я. Горбачевського МОЗ України, м. Тернопіль, Україна

Юрій І. Бондаренко
https://orcid.org/0000-0003-2681-5526
Кафедра патологічної фізіології, Тернопільський національний медичний університет імені І.Я. Горбачевського МОЗ України, м. Тернопіль, Україна

ХАРАКТЕРИСТИКА ТЕРМОПЛАСТИЧНИХ ПОЛІМЕРНИХ БАЗИСНИХ МАТЕРІАЛІВ ДЛЯ ОРТОПЕДИЧНИХ ЗУБНИХ ПРОТЕЗНИХ КОНСТРУКЦІЙ

Вступ. В даний час в стоматології існує широкий асортимент термопластичних полімерів для знімних конструкцій зубних протезів, які надзвичайно перспективні у сучасній стоматологічній практиці. Успішне протезування пацієнтів залежатиме від властивостей вибраних конструкційних матеріалів. Метою даної роботи було на основі огляду літературних джерел узагальнити сучасні відомості про застосування термопластичних базисних матеріалів для виготовлення знімних протезів і підвищення ефективності ортопедичного лікування пацієнтів з повним або частковим відсутністю зубів.

.**Методи.** Огляд літератури проводився за допомогою PubMed, Web of Science, SCOPUS, Google Scholar до січня 2024 року. Не було обмежень щодо дати публікації чи мови наукових джерел. Пошуки проводилися за термінами MeSH (Medical Subject Headings) з використанням таких пошукових термінів: «знімне протезування», «знімні протези», «стоматологічні базисні матеріали», «термопласти», «матеріалознавство», «адаптація». Використані методи: бібліографічний та аналітичний.

Результати та їх обговорення. Термопластичні матеріали характеризуються біоінертністю для організму людини, тому що не містять залишковий мономер. Ця група матеріалів володіє хорошою міцністю, гнучкістю, стійкістю до зовнішніх впливів, легкістю, еластичністю і високою естетичністю. Технологія інжекційного формування термопластичних полімерів дійсно розглядається як перспективний метод у сучасній стоматології для досягнення високих естетичних стандартів. Ця група матеріалів відрізняється відсутністю залишкового мономеру, що забезпечує їх біологічну безпечність, а також високим рівнем пластичності, точністю виготовлення протезів та широкою кольоровою гамою. Завдяки позитивним характеристикам сучасних термопластичних полімерів стало можливим виготовляти ортопедичні конструкції з високими естетичними та функціональними властивостями, які характеризуються еластичністю, легкістю та комфортом.

Висновок. Полімерні базисні пластмаси також не мають оптимальних фізико-механічних, біологічних і поверхневих характеристик, тому перспективним напрямом залишається пошук нових матеріалів для виготовлення знімних протезів.

Ключові слова: знімне протезування, базисні матеріали, термопласти, слизова оболонка, матеріалознавство, нейлоновий протез, ацетатний протез, акриловий протез, ортопедична стоматологія, адаптація.

Автор, відповідальний за листування: *Демкович Андрій Євгенович, Тернопільський національний медичний університет імені І.Я. Горбачевського МОЗ України, майдан Волі 1, Тернопіль, 46001, Україна*
e-mail: demkovushae@tdmu.edu.ua
+380979342501

ABBREVIATIONS
MeSH – Medical Subject Headings
PEEK – polyetheretherketones

INTRODUCTION / ВСТУП

In recent years a significant number of measures have been implemented to prevent the development of dental diseases. Despite these efforts, the prevalence of such diseases among the population remains high [1]. And, as a result, the need of patients for orthopedic treatment with partial or complete removable prostheses is increasing [2]. Everyone knows that untimely referral of patients to the imperfect materials and technologies in the manufacture of removable structures of dental prostheses lead to deterioration of the condition of the entire dental and jaw system and the organism as a whole [3, 4]. Currently, in dentistry there is a wide range of thermoplastic polymers for removable structures of dental prostheses, which are extremely promising in modern dental practice [5]. Thermoplastic materials are characterized by bioinertness for the human body, because they do not contain residual monomer. This group of materials has good strength, flexibility, resistance to external influences, lightness, elasticity and high aesthetics [6].

However, the experience of using thermoplastic polymers for the bases of removable prostheses has shown that, along with positive properties, there are also technological shortcomings that affect the quality and durability of these prosthetic constructions. Basically, it is the complexity of polishing thermoplastics, which leads to the rapid deterioration of the aesthetic characteristics of the removable prosthesis, the accumulation of microorganisms on its surface [7]. This leads to the complexity of wide practical implementation of these types of promising basic materials.

In the exploration of dental base materials, various testing methods are employed to examine their properties in detail. This includes investigating their dependence on chemical composition, structure, and processing methods. The success of patient prosthetics hinges on the properties of the chosen structural materials [8].

Purpose of the study was to summarize current information, based on a review of literary sources, on the use of thermoplastic base materials for the manufacture of removable prostheses and improves the effectiveness of orthopedic treatment of patients with complete or partial absence of teeth.

MATERIAL AND METHODS

The literature review is based on the analysis of a significant volume of digital publications, which were found as a result of a literature search on global databases, such as PubMed (https://pubmed.ncbi.nlm.nih.gov), Web of Science Core Collection (https://www.webofscience.com/wos/woscc/basic-search), Scopus (https://www.scopus.com) and Google Scholar (https://scholar.google.com.ua). A literature review was carried out to identify publications about the influence of orthopedic structures made of various materials on the homeostasis of the oral cavity, as well as the importance of changes in the of the oral cavity's homeostasis on adaptation to dental prostheses. The bibliographic research was conducted between 20 August 2023 and 20 January 2024 to analyze the most recent evidence. Searches using the MeSH (Medical Subject Headings) terms were conducted using synonyms and combinations of the following search terms: "removable prosthetics", "dental base materials", "thermoplastics" "materials science", and "adaptation". In addition to the electronic search, an analogical search was carried out in the bibliographic references of the selected articles. Used methods: bibliographic and analytical. At the first stage, a search for literary sources was conducted using key words. At the second stage, summaries of articles were studied and publications that did not meet the research criteria were excluded. At the third stage, the full texts of the selected articles were studied for compliance with the criteria for inclusion in the literature list and research relevance. The criteria for including publications in the sample that was subject to content analysis were the following: 1) coverage of modern information on the use of thermoplastic polymer base materials in the manufacture of removable prostheses; 2) compliance of research with the key principles of evidence-based medicine; 3) full-text indexing of the article in the PubMed scientometric database. Exclusion criteria were publications that did not meet the purpose of this review, results, publication language other than English and Ukrainian.

RESULTS AND DISCUSSION

A total of 89 sources of literature were selected and processed during the primary analysis, which included evidence-based randomized trials, systematic reviews, and others. After further systematization of the selected information using general scientific methods (analysis, synthesis, generalization, critical evaluation of the collected data), 60 most relevant sources remained. Currently, due to the introduction of current technologies in prosthetics with removable structures, the opportunities to raise and improve the quality of treatment with the help of removable dental prostheses have significantly expanded [9]. Many specialists, striving for the best, begin to gradually abandon the technology of hot hardening, compression molding, which is widespread, and move to a new level of dental production [10].

Thermoplastic polymers have become known in world dentistry since the middle of the last century, but the interest of domestic dentists and dental technicians in them arose in the last 10-15 years, due to the emergence of available information and equipment [11]. At that time, there were attempts to use different combinations of materials to obtain the bases of prostheses: based on polycarbonate, polyamides, polystyrene, which never found their use in dentistry.

Thermoplastic polymers can acquire plasticity and the required shape in a heated state. At the same time, in granular or powder form, the polymer enters the injection cylinder of the casting apparatus, where it warms up, plasticizes and enters the casting mold through the nozzle [12]. The technology of injection molding of thermoplastic polymers is considered as a promising technology in modern dentistry to achieve high aesthetic standards [13]. The general characteristic of this group of materials is the absence of residual monomer and, accordingly, their biological indifference, a high level of plasticity, precision during the manufacture of the prosthesis, and a wide range of colours. Thanks to the positive characteristics of modern thermoplastic polymers, it has become possible to manufacture orthopedic structures with high aesthetic and functional properties [5], which are characterized by elasticity, lightness and comfort [14].

It was proven that thermoplastic materials do not contain residual monomer, toxic and allergenic components. These polymer materials have good biocompatibility, which is very important for people with an allergic status, pathology of the gastrointestinal tract, diseases of the nervous and endocrine systems [6]. In addition, thermoplastic plastics are characterized by pronounced plasticity, unique shape memory, a large selection of colors, which makes it possible to expand the choice of partial and full prosthetics, the manufacture of immediate prostheses, prosthetic splint-dentures, splinting and improve their aesthetic qualities [15, 16].

Since the 80s of the last century, biologically neutral thermoplastic materials, which were previously used in other fields of medicine, began to be used in the manufacture of dental prostheses. These include nylon, polyoxymethylene, polypropylene, ethylene vinyl acetate, methyl methacrylate.

As a result of research by clinicians [17], it was found that the use of elastic base polymers, which absorb chewing pressure, leads to a decrease in resorption and atrophy of the alveolar bone of the jaws. Additionally, there is a reduction in the period of adaptation to dental prostheses [18].

Ongoing research aims to enhance the aesthetics and comfort of removable medical devices and prostheses [19]. One of such works is wide and mass advertising and informing the population about the properties of prostheses based on nylon, the physical properties of which are superior to the properties of some metals [20]. They are manufactured using the injection method, so they have an accurate fit and stable fixation [21]. They have high strength, medium hardness, resistance to high temperatures and chemicals [22]. Nylon removable prostheses have high flexibility, resist fractures well. Prostheses made of nylon are more comfortable and natural in the oral cavity of patients, invisible to others, due to good retention and aesthetic properties [23]. To create aesthetic prostheses, a stable dye is added to the composition of thermoplastics.

Nylons represent characteristic groups of amides, leading to the classification of such compounds as polyamides. The polar nature of amide groups allows them to form strong hydrogen bonds with each other [24]. Good physical and mechanical characteristics are achieved due to the high crystallinity of polyamides [17]. Basic thermoplastic polymers based on nylon in orthopedic dentistry are a material with very good properties in terms of physical and aesthetic parameters [25].

The elasticity of these prostheses allows for cushioning and leveling of the load on the supporting teeth and on the upper and lower jaw, which provides an even and desirable distribution of chewing pressure. The positive qualities of such removable prostheses are the fixing elements in the form of elastic nylon clasps, which have good aesthetic characteristics, do not adversely affect the surface of the supporting tooth, gently covering it [26]. According to the fastening mechanism, clasps can be classified as alveolar-dental, which redistribute the load on the supporting teeth and the alveolar part [27]. Fixation of nylon prostheses allows for an even distribution of chewing pressure, so

they are applicable in patients with periodontal disease [28-30]. Adaptation of patients to nylon prostheses occurs more easily and in a short time [31].

Compared to acrylic prostheses, nylon structures are many times stronger and safer [32]. According to its properties, the nylon prosthesis surpasses all materials available on the dental market. Nylon prostheses do not cause allergic reactions, as they do not contain monomer, do not change colour [33]. Patients who used both nylon and acrylic dental prostheses note that nylon prostheses are more comfortable, more natural and invisible to others due to their aesthetics [34]. These prostheses are very light and do not injure the gums.

Removable prostheses with a base and splinting multi-link clasp, combined, partial removable prostheses with alveolar clasps are obtained from nylon [35]. According to the authors, these prostheses are easy to grind and polish, which significantly reduces the work time of the dentist and dental technician [23]. After 6 months when using prostheses, the preservation of the thermoplastic colour was noted, since due to its high density, the material is practically non-hygroscopic and does not absorb moisture [25]. It was also noted the full compliance of the base with the prosthetic bed, good fixation of the structure, and the absence of inflammatory phenomena on the part of the oral mucosa [36-39].

A positive characteristic is the absence of porosity, properties of moisture saturation, therefore, after several years; such a structure does not change and does not adsorb colonies of microorganisms [40, 41]. Unlike acrylic prostheses, nylon prostheses have a positive effect on the criteria of microbiological and non-specific resistance of tissues and organs of the oral cavity [42]. Also, nylon prostheses have become an ambiguous option for acrylic and bugel dentures.

But nylon-based removable dentures are not without drawbacks. Some dentists have found disadvantages of removable prostheses constructions based on nylon materials, namely: 1) complexity in manufacturing and final processing; 2) the elasticity and flexibility of the denture causes accelerated atrophy of the alveolar ridge; 3) difficulties in repairing or the impossibility of rebasing a nylon prosthesis; 4) impossibility of using traditional methods of cleaning nylon prostheses; 5) fixation of the prosthesis gradually deteriorates due to flexible clasps [5].

During the final treatment of dental nylon prosthesis with paste or a hard brush, scratches remain on it, which contribute to the accumulation of microorganisms on the surfaces of dental prostheses [43]. To care for nylon prosthesis, it is necessary to use special products and soft brushes, because when cleaning with ordinary hygiene products, scratches are quickly formed on it, which contributes to the rapid accumulation of plaque on the prosthesis. After one year of using nylon prostheses, patients complained of a feeling of strong pressure in the area of the abutment teeth. In connection with the above-mentioned disadvantages of nylon prostheses, it is recommended to use them as temporary structures [14].

The most common nylon-based materials are: "Valplast", "Flexite" (USA), Israel ("Flexy-Nylon"), San Marino ("T.S.M. Acetal Dental"), Singapore ("Vertex Thermosens"), "Flexyplast" (Germany) [44].

In 1992, the Ukrainian scientist Vares E. Ya. proposed a method of casting under pressure to obtain the bases of dental appliances and prostheses. For this, foundry thermoplastic polymers polyethylene and polypropylene were taken. Propylene is a colorless polymer with no taste and characteristic smell. Constructions from this polymer had relatively good wear resistance compared to constructions from polyamides. Abrasion resistance increases with an increase in molecular weight and depends little on the content of polypropylene fractions and other structures [45].

Polypropylene is similar to nylon in its main properties, but differs in important physicochemical parameters, so polypropylene is used as a cheap alternative to nylon for the manufacture of orthopedic constructions [46]. It is a colorless polymer, without a characteristic smell and taste, it is much stronger than acrylates, softens at high temperatures, and has a high accuracy of fit. Polypropylene-based thermoplastic materials include "Proflex Clear Wire" (Dental Resources, USA), "Ndflex" (New Dental, Ukraine). Polypropylene prostheses are biologically neutral and stable in the oral environment due to the absence of monomers, catalysts, and other reactive inclusions [47]. Based on polypropylene "Lipol" was developed and widely used by professor E. Ya. Vares (Ukraine). This material was studied at the Lviv Polytechnic University.

The group of thermoplastics includes materials based on polyoxymethylene (polyformaldehyde, polymethylene oxide), which make it possible to manufacture many types of orthopedic constructions, the strength of which can be compared with metal ones [32].

Acetals are thermoplastic materials based on polyoxymethylene are the most stable thermoplastics. They have a crystalline molecular structure and the strength limit is ten times higher than the strength limit of acrylic polymer. It is believed that according to their physical and mechanical characteristics, they can be considered as a metal substitute [48]. It is known that due to the elasticity of the material, a more accurate and tight fit to the teeth and a more reliable fixation of the

prosthesis is ensured. Currently, thermoplastics based on polyoxymethylene are produced: "Aceplast" (Israel), "Dental D" (Italy), "T.S.M. Acetal Dental" (San Marino) and others [49]. Manufactured removable prostheses made of polyoxymethylene differ from other thermoplastics in greater rigidity, the least shrinkage during processing, resistance to solvents and surpass other thermoplastic polymers in dimensional stability, strength and rigidity. Due to its hardness, resistance to organic solvents and high melting point, polyoxymethylene is widely used for foundry molding [50].

Polymers, which included polyamides, had great strength, but, despite this, they turned out to be unsuitable for the technology of the base of dental prostheses, due to high water absorption, complex technical connection of it with artificial teeth, and high shrinkage [51].

In recent years, thermoplastic polymers based on methyl methacrylate have been widely used in orthopedic dentistry. The main properties of these materials include the absence of free monomer in their composition, high strength, and aesthetics [52]. This allows for the manufacturing of particularly thin bases for partial and complete removable prostheses without the need for metal structures, including saddles for buckled prostheses. Examples of monomer-free materials based on acrylic polymers are: "Flexite M.R." (USA), "Asru-free" (Israel), "The.r.mo Free" (San Marino), "Fusicril" (Italy), "Polyan" (Germany).

The least studied, but promising group of thermoplastic materials are polyetheretherketones (PEEK), which began to be used in dentistry only in recent years. These materials have a number of positive properties that determine their use in the manufacture of dental prostheses [53].

Polyetheretherketone is a semi-crystalline polymer composed of recurring units comprising three phenolic rings, two ester groups, and one keto group [54]. It exhibits a distinct set of characteristics and is recognized for its hard, opaque grayish-white appearance. Notably, among thermoplastic materials, PEEK boasts the highest melting point, reaching 335°C.

In terms of steam resistance, PEEK surpasses the rest of thermoplastics: products made from it can withstand short-term exposure in a steam atmosphere with a temperature of 300°C [55].

In the last decade, PEEK has found application in dentistry because it has a number of advantages compared to other polymers, metal alloys and ceramic restorations. PEEK is a bioinert material; its mechanical properties are similar to those of bone, dentin, and enamel. This polymer can be used in patients who refuse the presence of metals in the oral cavity due to unaesthetic appearance, metallic taste and other reasons, as well as in people with intolerance to acrylic and metal prostheses [56].

Currently, a number of PEEK-based materials certified for medical use are produced: "PEEK-Optima", "Motis", "Endolign" and "PEEK-Classix" (Invibio), "JUVORA Dental Disc" (Juvora Invibio Ltd.), "VESTAKEEP-PEEK" (Evonik Industries AG), "Bio XS" (Bredent), "Dentokeep PEEK disc" (NT-Trading), "KetaSpire PEEK" (Solvay).

Due to its mechanical and biological properties, polyetheretherketone is a suitable material for the construction of fixed and removable dental prostheses. Despite the limited experience of using PEEK prostheses in clinical practice, they demonstrated acceptable aesthetic and functional characteristics [57].

PEEK dentures can be manufactured in two ways: using CAD/CAM systems or injection molding. According to these methods of application, PEEK is produced in the form of blocks for milling, in granular form and in the form of tablets. For the milling process using CAD/CAM technologies, PEEK blanks undergo industrial pressing under standardized conditions, such as pressure, temperature regime for the required period of time. For pressing of granulated PEEK, a preheated muffle furnace with a plunger is placed in a vacuum press [53].

Analysis of the literature shows that there is very little data on the use of PEEK as a material for the manufacture of removable prostheses [58]. Only a few groups of researchers successfully used PEEK as a material for removable prosthetics: L. S. Silva et al (2023), K. P. Parate et al. (2023) [59, 60].

PEEK prosthesis is lighter than cobalt-chromium prosthesis and has no metal parts, which is acceptable to patients. There is also the potential to create smaller, more hygienic prostheses that allow reducing the area covered by the mucous membrane [54]. PEEK has greater flexibility compared to cobalt-chromium alloys, which create high stress due to the stiffness of the material [55]. The flexibility of PEEK will reduce the load on the supporting teeth. This allows you to avoid the main disadvantages when using metals as clasps of dental prostheses and prevent fatigue failure [58].

The main disadvantages of PEEK prostheses are gray color and opacity, which limits its use. Therefore, in order to improve its aesthetic qualities, manufacturers recommend lining it with various polymer composites. However, the inert and hydrophobic surface of PEEK impairs its connection with other dental materials [55].

For the connection of PEEK with acrylic plastic and artificial teeth, the most suitable method is mechanical retention due to the creation of through holes on the base of the artificial tooth or thin grooves along the edge

of the acrylic base, because the adhesion indicators between thermoplastic materials and acrylic teeth are quite low [52].

In addition, optimal ways of connecting PEEK with other structural materials have not yet been found. Further laboratory and clinical studies covering all aspects of the material's properties and clinical applications are needed in order for its use is based on sound scientific evidence.

CONCLUSIONS / ВИСНОВКИ

At the moment, there is a wide range of basic materials, but the fact that not all of them have stood the test of time, and some of them need improvement, is evidence of the need for efforts by finding new thermoplastics and optimizing their manufacturing technology. No polymer has optimal physico-mechanical, biological and surface characteristics, so the search for new materials for the manufacture of removable prostheses remains a promising direction.

AUTHOR CONTRIBUTIONS / ВКЛАД АВТОРІВ

All authors substantively contributed to the drafting of the initial and revised versions of this paper. They take full responsibility for the integrity of all aspects of the work.

FUNDING / ДЖЕРЕЛА ФІНАНСУВАННЯ

None.

CONFLICT OF INTEREST / КОНФЛІКТ ІНТЕРЕСІВ

The authors declare no conflict of interest.

REFERENCES/СПИСОК ЛІТЕРАТУРИ

1. Lysokon Y, Bandrivsky YL, Luchynskyi MA. Analysis of the results of treatment of destructive forms of apical periodontitis with osteotropic drugs in a short term. *Wiadomosci lekarskie.* 2022;75(1):228-231. https://doi.org/10.36740/WLek202201214
2. Carra MC, Rangé H, Swerts PJ, Tuand K, Vandamme K, Bouchard P. Effectiveness of implant-supported fixed partial denture in patients with history of periodontitis: A systematic review and meta-analysis. *J Clin Periodontol.* 2022;49(24):208-223. https://doi.org/10.1111/jcpe.13481
3. Hasiuk P, Malko N, Vorobets A, Ivanchyshyn V, Rosolovska S, Korniyenko M, et al. The intensity of chronic catarrhal gingivitis in children depending on the age. *Wiadomości Lekarskie*. 2020;73(5):846-849. https://doi.org/10.36740/WLek202005102
4. Demkovych AYe, Bondarenko YuI, Fastovets OO, Hrad AO, Hasiuk PA, Denefil OV. State of collagenolysis in experimental periodontitis of bacterial-immune genesis and its correction with flavonol. *Medicni perspektivi.* 2021;26(2):26-32. https://doi.org/10.26641/2307-0404.2021.2.234488
5. Tashiro S, Kawaguchi T, Hamanaka I, Takahashi Y. Bond strength of artificial teeth to thermoplastic denture base resin for injection molding. *Dent Mater J.* 2021;40(3):657-663. https://doi.org/10.4012/dmj.2020-183
6. Hinz S, Bensel T, Bömicke W, Boeckler AF. In Vitro analysis of the mechanical properties of hypoallergenic denture base resins. *Materials (Basel).* 2022;15(10):3611. https://doi.org/10.3390/ma15103611
7. D'Ambrosio F, Santella B, Di Palo MP, Giordano F, Lo Giudice R. Characterization of the oral microbiome in wearers of fixed and removable implant or non-implant-supported prostheses in healthy and pathological oral conditions: A narrative review. *Microorganisms.* 2023;11(4):1041. https://doi.org/10.3390/microorganisms11041041
8. Khilinich YeS, Nidzelsky MYa, Davydenko VYu, Kuznetsov VV, Davydenko GM. Techniques to study indicators of temperature in foundation area and pressure onto the mucous membrane from removable laminar dentures. *Actual Problems of the Modern Medicine: Bulletin of Ukrainian Medical Stomatological Academy.* 2019;4(19):73-76. https://doi.org/10.31718/2077-1096.19.4.73
9. Mendoza-Carrasco I, Hotta J, Sugio CYC, et al. Nonmetal clasp dentures: What is the evidence about their use? *J Indian Prosthodont Soc*. 2020;20(3):278-284. https://doi.org/10.4103/jips.jips_459_19
10. Zapara PS. Comparative evaluation of the quality of the recovery of chewing effectiveness, in the treatment of patients with removable orthopedic dentures made according to various laboratory technologies, based on data electro-myographic research. *Novini Stomatologii.* 2019;2:50-54.
11. Gupta A, Alifui-Segbaya F, Hasanov S, et al. Material extrusion of thermoplastic acrylic for intraoral devices: Technical feasibility and evaluation. *J Mech Behav Biomed Mater*. 2023;143:105950. https://doi.org/10.1016/j.jmbbm.2023.105950
12. Fazel Y. Basics of packaging mass processing. Packing mass is the key to high-quality casting. *Zubnoe protezirovanie.* 2020;2:40-44.

13. Mc Enhill S. A set of prostheses “in one day” using virtual planning. *Sovremennaya ortopedycheskaya stomatolohiya*. 2019;32:52-55.
14. Takakusaki K, Murakami N, Wada J, et al. Effect of retention hole designs in artificial teeth on failure resistance of the connection with thermoplastic resin. *Dent Mater J*. 2022;41(4):573-579. https://doi.org/10.4012/dmj.2021-328
15. Freiheffer K. Treatment with splints. Biological prosthetics – part 2. *Zubnoe protezirovanie.* 2019;2:12-19.
16. Caprina L., Lazzeri R. Daily practice of making complete removable immediate dentures. *Zubnoe protezirovanie*. 2020;4:34-44.
17. Macura-Karbownik A, Chladek G, Żmudzki J, Kasperski J. Chewing efficiency and occlusal forces in PMMA, acetal and polyamide removable partial denture wearers. *Acta Bioeng Biomech*. 2016;18(1):137-144. https://doi.org/10.5277//ABB-00357-2015-03
18. Kawaguchi T, Lassila LVJ, Baba H, et al. Effect of cellulose nanofiber content on flexural properties of a model, thermoplastic, injection-molded, polymethyl methacrylate denture base material. *J Mech Behav Biomed Mater*. 2020;102:103513. https://doi.org/10.1016/j.jmbbm.2019.103513
19. Tkachenko IM, German SA, Berezhna EO, Andrienko KU, Izotova AO. Justification of the design of the denture with claspless fixation at the mesio-distal inclination of the teeth. *Ukrainian Dental Almanac.* 2019;2:55-58. https://doi.org/10.31718/2409-0255.2.2019.11
20. Le Bars P, Bandiaky ON, Le Guéhennec L, Clouet R, Kouadio AA. Different polymers for the base of removable dentures? Part I: a narrative review of mechanical and physical properties. *Polymers (Basel).* 2023;15(17):3495. https://doi.org/10.3390/polym15173495
21. Nikolishin IA, Nikolishina EV, Dvornik VM, Dobrovolsky OV, Dobrovolska OV. Features of fixation of removable plate prostheses. *Bulletin of problems biology and medicine.* 2020;4:352-356. https://doi.org/10.29254/2077-4214-2020-4-158-352-356
22. Hasiuk P, Kindiy D, Vorobets A, Kindiy V, Demkovych A, Odzhubeiska O. Analysis of the advisability of using different types of base plastics by studying the needs of the population in removable prosthesis. *Wiadomosci Lekarskie*. 2022;75(12):3055-3059. https://doi.org/10.36740/WLek202212128
23. Zeidan AAE, Sherif AF, Baraka Y, et al. Evaluation of the effect of different construction techniques of CAD-CAM milled, 3D-printed, and polyamide denture base resins on flexural strength: an in Vitro comparative study. *J Prosthodont.* 2023;32(1):77-82. https://doi.org/10.1111/jopr.13514
24. Chindarungruangrat A, Eiampongpaiboon T, Jirajariyavej B. Effect of various retentive element materials on retention of mandibular implant-retained overdentures. *Molecules.* 2022;27(12):3925. https://doi.org/10.3390/molecules27123925
25. Gokay GD, Durkan R, Oyar P. Evaluation of physical properties of polyamide and methacrylate based denture base resins polymerized by different techniques. *Niger J Clin Pract.* 2021;24(12):1835-1840. https://doi.org/10.4103/njcp.njcp_469_20
26. Kalashnikov DV, Kindiy DD, Korol DM, Kindiy VD. Analysis of denture base impact on the denture foundation area tissues. *World of Medicine and Biology.* 2020;1(71):58-62. https://doi.org/10.26724/2079-8334-2020-1-71-58-62
27. Demkovych A. Effects of flavonol quercetin on activity of lipid peroxide oxidation in experimental bacterial-immune periodontitis. *Interventional Medicine and Applied Science.* 2019;11(1):55-59. https://doi.org/10.1556/1646.10.2018.48
28. Demkovych A, Rubas L, Luchynskyi V, Luchynska Y, Stoikevych H, Machogan V. Changes of ultrastructural organization in periodontal complex components in experimental periodontitis and its correction with quercetin. *Pharmacia.* 2022;69(2):563-569. https://doi.org/10.3897/pharmacia.69.e82128
29. Bandrivsky Yu, Bandrivska O, Bandrivska N, Bedenyuk O, Piasetska L, Dutko K. The effect of complex treatment on some hematological and hemostasiological indicators during the treatment of generalized periodontitis in patients with different blood group affiliation. *Pharmacia.* 2022;69(4):1027-1033. https://doi.org/10.3897/pharmacia.69.e87118
30. Sylenko BYu, Dvornyk VM, Sylenko YuI, Sylenko GY. Electromyography indicators in different periods of using of the removable dentures in patients with acrylate intolerance. *Ukrainian Dental Almanac.* 2020;1:51-56. https://doi.org/10.31718/2409-0255.1.2020.07
31. Jadhav V, Deshpande S, Radke U, Mahale H, Patil PG. Comparative evaluation of three types of denture base materials with saliva substitute before and after thermocycling: An in vitro study. *J Prosthet Dent.* 2021;126(4):590-594. https://doi.org/10.1016/j.prosdent.2020.07.014
32. Polychronakis N, Sykaras N, Polyzois G, Lagouvardos P. Removal of denture adhesives from PMMA and Polyamide denture base materials. *J Appl Oral Sci.* 2021;29:e20200448. https://doi.org/10.1590/1678-7757-2020-0448
33. Borg H, Azer SS, El Hadary A, Helaly O, Shoeib A, Hassan M. Evaluation of enamel wear by 3 occlusal splint materials: An in vitro study. *J Prosthet Dent.* 2023;130(5):743.e1-743.e6. https://doi.org/10.1016/j.prosdent.2023.08.034
34. Demkovych A. Endogenous intoxication in development of experimental periodontitis of bacterial-immune genesis. *Folia Medica.* 2023;65(1):149-154. https://doi.org/10.3897/folmed.65.e71970
35. Demkovych A, Hasiuk P, Korobeinikova Y, Shcherba V, Korobeinikov L. Dynamics of changes of C-reactive protein level in blood serum in the development and course of experimental periodontitis and their

correction by flavonol. *Wiadomosci Lekarskie.* 2022;75(2):451-455. https://doi.org/10.36740/WLek202202122
36. Makeyev VF, Hunovskyi YaR. Comparative evaluation of adhesive ability of microorganisms to thermoplastic and acrylic base polymers for removable dental prostheses polished with different pastes. *Ukrainian Dental Almanac.* 2022;2:22-27. https://doi.org/10.31718/2409-0255.2.2022.04
37. Demkovych A, Kalashnikov D, Hasiuk P, Zubchenko S, Vorobets A. The influence of microbiota on the development and course of inflammatory diseases of periodontal tissues. *Frontiers in Oral Health.* 2023;4:1237448. https://doi.org/10.3389/froh.2023.1237448
38. Ozyilmaz OY, Kara O, Akin C. Evaluation of various denture cleansers on color stability and surface topography of polyetherketoneketone, polyamide, and polymethylmethacrylate. *Microsc Res Tech.* 2021;84(1):3-11. https://doi.org/10.1002/jemt.23558
39. Chuchulska B, Hristov I, Dochev B, Raychev R. Changes in the surface texture of thermoplastic (monomer-free) dental materials due to some minor alterations in the laboratory protocol-preliminary study. *Materials (Basel).* 2022;15(19):6633. https://doi.org/10.3390/ma15196633
40. Kuz HM, Teslenko OI, Yerys LB, Balia HM, Kuz VS. Results of treatment of edentulous patients with dentures, made of «Vertex Thermosense» (thermoplastic material). *Wiad Lek.* 2021;74(6):1433-1438. https://doi.org/10.36740/WLek202106127
41. Vares EYa. Manufacturing of dentures and orthodontic appliances from injection molded thermoplastics: manual. *Lviv;* 1999. 263p.
42. Schierz O, Schmohl L, Hahnel S, Rauch A. Polyoxymethylene as material for removable partial dentures-a literature review and illustrating case report. *J Clin Med.* 2021;10(7):1458. https://doi.org/10.3390/jcm10071458
43. Fathy SM, Abdel-Halim MS, El-Safty S, El-Ganiny AM. Evaluation of polymethyl-methacrylate and acetal denture base resins processed by two different techniques before and after nano-chlorohexidine surface treatment. *BMC Oral Health.* 2023;23(1):985. https://doi.org/10.1186/s12903-023-03718-0
44. Alshaiba HA, Khalifa N, Doory ZA, El-Damanhoury HM. Wear, fatigue and fracture resistance of different monolithic CAD/CAM onlays as abutments for acetal resin or cobalt-chromium removable partial denture frameworks. *Int J Prosthodont.* 2023;1:1-35. https://doi.org/10.11607/ijp.8641
45. Al-Somaiday HM, Rafeeq AK, Al-Samaray ME. Effect of different surface modifications of acrylic teeth and thermocycling on shear bond strength to polycarbonate denture base material. *Int J Biomater.* 2022;2022:9855836. https://doi.org/10.1155/2022/9855836
46. He Z, Wu Q, Zhang N, et al. A digital chairside repair protocol for removable partial dentures with polyetheretherketone frameworks. *J Prosthet Dent.* 2023;3913(23):486-489. https://doi.org/10.1016/j.prosdent.2023.07.017
47. Siewert B. Treatment success and service life of implant-supported PEEK complete dentures. *New in dentistry.* 2020;7:49-53.
48. Micovic D, Mayinger F, Bauer S, Roos M, Eichberger M, Stawarczyk B. Is the high-performance thermoplastic polyetheretherketone indicated as a clasp material for removable dental prostheses? *Clin Oral Investig.* 2021;25(5):2859-2866. https://doi.org/10.1007/s00784-020-03603-y
49. Peng TY, Ogawa Y, Akebono H, Iwaguro S, Sugeta A, Shimoe S. Finite-element analysis and optimization of the mechanical properties of polyetheretherketone (PEEK) clasps for removable partial dentures. *J Prosthodont Res.* 2020;64(3):250-256. https://doi.org/10.1016/j.jpor.2019.07.012
50. Liu Y, Fang M, Zhao R, et al. Clinical applications of polyetheretherketone in removable dental prostheses: accuracy, characteristics, and performance. *Polymers (Basel).* 2022;14(21):4615. https://doi.org/10.3390/polym14214615
51. Hao J, Murakami N, Yamazaki T, et al. Flexural and fatigue properties of polyester disk material for milled resin clasps. *Dent Mater J.* 2021;40(6):1359-1364. https://doi.org/10.4012/dmj.2021-037
52. Sun J, Wang L, Wang J, et al. Characterization and evaluation of a novel silver nanoparticles-loaded polymethyl methacrylate denture base: In vitro and in vivo animal study. *Dent Mater J.* 2021;40(5):1100-1108. https://doi.org/10.4012/dmj.2020-129
53. Muralidharan C, Schneider RL, Kotowske S. CAD-CAM denture teeth made on cast metal removable partial denture frameworks. *J Prosthet Dent.* 2022;3913(22):00325-0. https://doi.org/10.1016/j.prosdent.2022.04.030
54. Feng ZH, Zhong S, Zhang X, et al. Exploration of making removable partial denture by digital technology. *Zhonghua Kou Qiang Yi Xue Za Zhi.* 2023;58(4):354-358. https://doi.org/10.3760/cma.j.cn112144-20221206-00604
55. Hussein MO. Performance of graphene-based and polyether-ether-ketone polymers as removable partial denture esthetic clasp materials after cyclic fatigue. *Polymers (Basel).* 2022;14(15):2987. https://doi.org/10.3390/polym14152987
56. LÜmkemann N, Eichberger M, Murphy RJ, Stawarczyk B. Suitability of the new Aryl-Ketone-Polymer indicated for removable partial dentures: Analysis of elastic properties and bond strength to denture resin. *Dent Mater J.* 2020;39(4):539-546. https://doi.org/10.4012/dmj.2019-125
57. Lo Russo L, Chochlidakis K, Caradonna G, Molinelli F, Guida L, Ercoli C. Removable partial dentures with polyetheretherketone framework: the influence on residual ridge stability. *J Prosthodont.* 2022;31(4):333-340. https://doi.org/10.1111/jopr.13408
58. Gentz FI, Brooks DI, Liacouras PC, et al. Retentive forces of removable partial denture clasp assemblies made from polyaryletherketone and cobalt-chromium: a

comparative study. *J Prosthodont.* 2022;31(4):299-304. https://doi.org/10.1111/jopr.13398

59. Parate KP, Naranje N, Vishnani R, Paul P. Polyetheretherketone Material in Dentistry. *Cureus.* 2023;15(10):46485. https://doi.org/10.7759/cureus.46485

60. Silva LS, Bento VAA, Brunetto JL, Pesqueira AA. Polyetheretherketone materials for removable partial denture frameworks: an integrative review. *Pesqueira Gen Dent*. 2023;71(4):58-62. PMID: 37358585

Received 27.04.2024
Accepted 25.05.2024

Одержано 27.04.2024
Затверджено до друку 25.05.2024

INFORMATION ABOUT THE AUTHORS / ВІДОМОСТІ ПРО АВТОРІВ

Poliukhovych Yuliia – post graduate student at Orthopedic Dentistry Department of I. Horbachevsky Ternopil National Medical University

Demkovych Andrii – professor of Orthopedic Dentistry Department of I. Horbachevsky Ternopil National Medical University, DSc, PhD, MD, professor

Bondarenko Yurii – professor of Pathophysiology Department of I. Horbachevsky Ternopil National Medical University, DSc, PhD, MD, professor