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SVOJSTVA I PRIMENA DENTALNIH POLIAMIDA

PROPERTIES AND APPLICATIONS OF DENTAL POLYAMIDES

Nikola R. Gligorijević[1], Marko A. Igić[1,2], Milena M. Kostić[1,2], Ana S. Pejčić[3,4]

[1]UNIVERZITET U NIŠU, MEDICINSKI FAKULTET, NIŠ, PREDMET STOMATOLOŠKA PROTETIKA, NIŠ, SRBIJA
[2]KLINIKA ZA STOMATOLOGIJU NIŠ, ODELJENJE ZA STOMATOLOŠKU PROTETIKU, NIŠ, SRBIJA
[3]UNIVERZITET U NIŠU, MEDICINSKI FAKULTET, PREDMET ORALNA MEDICINA I PARODONTOLOGIJA NIŠ, SRBIJA
[4]KLINIKA ZA STOMATOLOGIJU, ODELJENJE ZA ORALNU MEDICINU I PARODONTOLOGIJU, NIŠ, SRBIJA

[1]UNIVERSITY OF NIŠ, FACULTY OF MEDICINE, DEPARTMENT OF DENTAL PROSTHODONTICS, NIS, SERBIA
[2] CLINIC OF DENTISTRY NIŠ, DEPARTMENT OF DENTAL PROSTHODONTICS, NIS, SERBIA
[3]UNIVERSITY OF NIŠ, FACULTY OF MEDICINE, DEPARTMENT OF ORAL MEDICIINE AND PERIODONTOLOGY, NIS SERBIA
[4]CLINIC OF DENTISTRY NIŠ, DEPARTMENT OF ORAL MEDICIINE AND PERIODONTOLOGY, NIS SERBIA

Sažetak

Uvod: *Ispitivanjem brojnih termoplastičnih i fleksibilnih materijala koji će estetski i funkcionalno prevazići akrilate koji se koriste za izradu zubnih proteza otkriveni su poliamidi kao materijali sa velikom potencijalnom primenom u stomatološkoj protetici.*
Cilj *rada je bio opis poliamidnih materijala za izradu parcijalnih zubnih proteza.*
Materijal i metode: *Glavni metodološki pristup ove studije bio je sistematska pretraga literature u dve elektronske baze podataka: Google Scholar i PubMed upotrebom prethodno definisanih kombinacija ključnih reči.*
Rezultati: *Prednost poliamidnih proteza je komfornost i lako privikavanje pacijenta, uz očuvana optimalna mehanička i fizička svojstva. Proteze su fleksibilne ali dovoljno rigidne da su otporne na udare i lom. Zbog male specifične težine poliamidne proteze su lake, izuzetno su tanke i ne smetaju pacijentu pri govoru. Odlična estetika obezbeđena je izborom boja i visokom translucencijom materijala što obezbeđuje da se meko tkivo providi kroz protezu i daje prirodniji izgled proteze u ustima pacijenta.*
Zaključak: *Poliamidi, za razliku od akrilata, ne sadrže rezidualni monomer, pa imaju zavidni stepen biokompatibilnosti. Mogu se izrađivati kao totalne ili parcijalne proteze, u kombinaciji sa Cr-Co skeletom ili krunama i mostovima.*

Ključne reči: *proteze, poliamidi*

Corresponding author:
Nikola Gligorijević,DDM, PhD Student,
dr Zoran Đinđić Blvd 81,
dr.gligorijevicnikola@gmail.com
+381653366646

Abstract

Introduction: *By examining numerous thermoplastic and flexible materials that would aesthetically and functionally surpass acrylates used for the production of dental prostheses, polyamides were discovered as materials with great potential application in prosthodontics.*
The aim *of this study was to describe polyamide materials used for the production of partial dentures.*
Material and methods: *The main methodological approach of this study was a systematic search of the literature in two electronic databases: Google Scholar and PubMed using pre-defined keyword combinations.*
Results: *The advantage of polyamide dentures is the comfort and ease of accommodation of the patient, with preserved optimal mechanical and physical properties. The dentures are flexible but rigid enough to be resistant to shock and fractures. Due to their low specific weight, polyamide dentures are light, extremely thin and do not interrupt patient speech. Excellent aesthetics are provided by a high choice of working colors and high translucency of the material, which ensures that the soft tissue that's covered by the denture base or clasp is seen through the prosthesis and gives it a more natural appearance in the patient's mouth.*
Conslusion: *Polyamides, unlike acrylates, do not contain residual monomers, so they have an greater degree of biocompatibility. They can be used for the production of both complete and partial dentures, in combination with a Cr-Co skeleton, or crowns and bridges.*

Key words: *dentures, polyamides*

Uvod

Gubitak zuba je funkcionalni i estetski problem, koji su ljudi kroz vekove rešavali izradom zubnih proteza od različitih materijala. Revolucionarno otkriće akrilatnih polimera tridesetih godina prošlog veka učinilo je pločaste zubne proteze učinkovitim, lakim za izradu i dostupnim svima. Nedostaci pločastih proteza izrađenih od akrilatnih polimera jesu gingivalni prenos pritiska žvakanja, česte frakture, alergija na rezidualni monomer, mehanička iritacija oralne sluzokože rigidnim proteznim sedlom i teško prilagođavanje podminiranim područjima, velika poroznost i adherentnost. Sastav akrilata je vremenom neznatno modifikovan, ali nedostaci u vidu krtosti, rigidnosti, pa samim tim i sklonosti lomu i trošenju, kao i otpuštanja nevezanih komponenti (rezidualnog monomera) nisu prevaziđeni[1,2]. Mehaničke karakteristike akrilata poboljšane su uvođenjem injekcione tehnike polimerizacije pod pritiskom, šezdesetih godina dvadesetog veka. Nova metoda je otvorilila put alternativnim materijalima, koji se mogu aplikovati na isti način.

U svrhu pronalaska materijala koji će estetski i funkcionalno prevazići akrilate, ispitivani su brojni termoplastični i fleksibilni materijali[3]. Materijali koji se danas koriste za izradu fleksibilnih proteza jesu poliamidi i na bazi su najlonske plastike kombinovane sa elastomernim smolama, koje im daju određenu fleksibilnost uz mogućnost ojačavanja vlaknima[4]. Proteze od dentalnih poliamida obezbeđuju optimalne fizičke i mehaničke karakteristike: čvrstoću, fleksibilnost, transparenciju, veliku otpornost na udar, stabilnu boju, nerastvorljivost i neporoznost, prebojavanje organskim bojama, dobru dimenzionalnu stabilnost, a obrađuju se i poliraju jednako lako kao akrilati.

Cilj rada bio je opis poliamidnih materijala za izradu parcijalnih zubnih proteza, uz korišćenje podataka elektronskih istraživačkih baza. Glavni metodološki pristup ove studije bila je pretraga u dve elektronske baze podataka: Google Scholar i PubMed. Kombinacije ključnih reči korišćenih za sistematsko traženje literaturedate su u tabeli 1.

Introduction

Tooth loss is a functional and aesthetic problem that people have solved over the centuries by making dentures using different materials. The revolutionary discovery of acrylic polymers in the 1930s made removable partial dentures effective, easy to make and accessible to all. Disadvantages of removable partial dentures made of acrylate polymers are: gingival transmission of masticatory pressure, frequent fractures, allergy to residual monomer, mechanical irritation of the oral mucosa with rigid denture saddle and difficult adjustment to undercut areas, high porosity and adherence. The chemical composition of acrylates has been slightly modified over time, but the disadvantages in the form of brittleness, rigidity, and thus the tendency to fracture and wear, as well as the release of unbound components (residual monomer) have not yet been overcome[1,2]. The mechanical properties of acrylates were improved by the introduction of injection molding polymerization techniques in the 1960s.This new method paved the way for alternative materials that can be applied in the same way.

In order to find a material that will aesthetically and functionally surpass acrylates, a number of thermoplastic and flexible materials have been tested[3]. The materials that are today in use of making flexible dentures are polyamides, and are based on nylon plastics combined with elastomeric resins that give them some flexibility with the possibility of fiber reinforcement[4]. Polyamide dentures provide optimal physical and mechanical characteristics: strength, flexibility, transparency, high impact resistance, stable color, insolubility and non-porosity, they are stained using organic stains, good dimensional stability, and are processed and polished as easily as acrylates.

The aim of this paper was to describe polyamide materials used for the production of partial dentures using data from scientific research databases. The main methodological approach of this study was to search scientific publication in two electronic databases: Google Scholar and PubMed. The keyword combinations used for the systematic literature search are given in Table 1.

Tabela 1. Kombinacija ključnih reči korišćenih za pretragu baza podataka naučnih časopisa
Table 1. Combination of keywords used to search databases of scientific journals

polyamides + dentistry
polyamides + dental use
polyamides + prosthodontics
polyamides + dentures

Hemijski sastav dentalnih poliamida

Poliamidi, koji se koriste u stomatologiji, nastaju kondenzacionom rekacijom između diamina NH2-(CH2)6-NH2 i dibazične kiseline, CO2H-(CH2)4-COOH[5,6]. Kristalna forma materijala omogućava njegovu slabu rastvorljivost, visoku otpornost na toplotu, visoku čvrstoću i duktilnost (Slika 1)[7,8]. Proteze izrađene od termoplastičnog poliamida su polufleksibilne ipolurigidne nadoknade. Njihove prednosti su, prvenstveno, veliki komfor i lako prilagođavanje pacijenata na nošenje proteze.

Dentalni poliamidi indikovani su u izradi totalnih i parcijalnih proteza injihovom podlaganju. Poliamidne proteze posebno sukorisne u slučajevima podminiranosti grebenova, kada nije preporučena hirurška intervencija. Lako se mogu uključiti u složene protetičke radove i kombinovati sa Co-Cr metalnim konstrukcijama i fiksnim protetičkim radovima[9,10].

Chemical composition of dental polyamides

Polyamides used in dentistry are formed by condensation reaction between diamine NH2-(CH2)6-NH2 and dibasic acid, CO2H-(CH2)4-COOH[5,6]. The crystalline form of the material gives it its poor solubility, high heat resistance, high strength and ductility (Figure 1)[7,8]. Dentures made of thermoplastic polyamides are semi-flexible and semi-rigid restorations. Their advantage is, primarily, in great comfort and easy getting used to this type of dentures for patients.

Dental polyamides are indicated in the production of complete and partial dentures and their lining. Polyamide dentures are especially useful in cases of ridge undercuts, when surgery is not recommended. They can be easily included in complex prosthodontic restorations and combined with Co-Cr metal constructions and fixed prosthodontic restorations[9,10].

Slika 1. Kristalna struktura poliamidnog materijala
Figure 1. Crystal structure of polyamide material

Fizičko-mehanička svojstva

Prednost poliamida, u odnosu na akrilatne materijale, jeste njihova otpornost na lom, zahvaljujući fleksibilnim svojstvima i velikom modulu savijanja, te se lako prilagođavaju podminiranim zonama usne duplje i delovima zuba ispod protetskog ekvatora, dajući parcijalnoj mobilnoj protezi optimalnu retenciju i stabilizaciju . Poliamidi pokazuju veću otpornost na udar i ponavljano naprezanje, kao i veću otpornost na habanje u odnosu na akrilate[11]. Poliamidne parcijalne proteze poseduju veću elastičnu memoriju i otpornost na deformaciju, uprkos cikličkom naprezanju[11,12]. Imaju veću mogućnost savijanja u granicama proporci-onalnosti i nizak modul elastičnosti[13,14]. Poliamidi suhigroskopni materijali, te stoga njihov sadržaj vlage varira u odnosu na uslove okoline. Poseduju nizak koeficijent linearne ekspanzije i galvanske provodljivosti[11,12].

Bez obzira na superiorna mehanička svojstva u odnosu na akrilate , ipak postoje ozbiljna ograničenja, kao što su poteškoće u obradi i dimenzionalna stabilnost[12,15]. Kako se poliamidi ne vezuju za hladno polimerizovane akrilate[16], reparaturei podlaganja su komplikovani i moraju se izvoditi u laboratoriji, mada se intezivno radi na unapređenju ovog svojstva[17,18]. Pored svih pozitivnih efekta, fleksibilnost poliamidnih materijala može dovesti do neravnomernog opterećenja potporne sluzokože i kosti , posebno mandibule[19,20].

Fleksibilnost poliamida, sem otpornosti na prelom, omogućava izradu kukica u boji gingive ili zuba, ugradnju atečmena, čineći parcijalne proteze, izrađene od ovog materijala, estetski mnogo boljim nadoknadama (non-metal clasp dentures). Takođe, moguće je u jednom komadu izraditi sve delove parcijalne proteze (kukice, baza, mala i velika spojnica), što im omogućava kompaktnost, funkcionalnost i trajnost[21]. Superfleksibilna svojstva poliamidnih smola, posebno dolaze do značaja kod slučajeva u kojima imamo podminirana mesta na preostalom bezubom grebenu, čineći stavljanje i skidanje proteze znatno lakšim za pacijenta[22-24].

Estetska svojstva i komfornost

Odličan estetski učinak poliamidnih parcijalnih proteza obezbeđuje visoka translucencija materijala, tako da se boja mekog tkiva providi kroz protezu, što daje

Physical and mechanical properties

The advantage of polyamides over acrylic materials is their resistance to fracture, thanks to their flexible properties and large bending modulus, and the fact that they easily adapt to undercut zones of the oral cavity and parts of teeth below the prosthetic equator, giving partial mobile dentures optimal retention and stabilization. Polyamides show higher impact resistance and repeated stress resistance as well as higher wear resistance compared to acrylates[11]. Polyamide partial dentures have greater elastic memory and resistance to deformation despite being under cyclic stress[11,12]. They have a greater ability to bend in proportional limits and low modulus of elasticity[13,14]. Polyamides are hygroscopic materials and thus its theirmoisture content varies in relation to environmental conditions. They have a low coefficient of linear expansion and galvanic conductivity[11,12].

Regardless of the superior mechanical properties compared to acrylates, there are still serious limitations for their use such as processing difficulties and dimensional stability[12,15]. As polyamides do not bind to cold polymerized acrylates[16], repairs and lining of polyamide dentures are complicated and must be performed in the laboratory, although intensive work is being done to improve this property[17,18]. In addition to its positive effect, the flexibility of polyamide materials can lead to uneven loading of the supporting mucosa and bone, especially the mandible[19,20].

The flexibility of polyamides, apart from their resistance to breakage, enables the making of clasps in the color of the gingiva or teeth, the use of attachments, making partial dentures made of this material aesthetically a much better esthetic denture solution (non-metal clasp dentures). Also, it is possible to make all parts of a partial denture (clasps, base, small and large joint) in one piece, which allows them to be compact, functional and durable[21]. The super flexibility of polyamide resins is especially important in cases where we have undercuts on the remaining edentulous ridge, making the insertion and removal of the denture much easier for the patient[22-24].

Aesthetic properties and comfort

The excellent aesthetic effect of polyamide partial dentures is provided by the high translucency of the material, so that the color of the soft tissue is seen through the

prirodniji izgled u ustima pacijenta. Za njihovo bojenje koriste sepigmenti koji su bez kadmijumovih i ostalih metalnih oksida[25].

S obziromna toda su male specifične težine, izrađuju se u veoma tankom sloju (0,5 mm), pa je navikavanje lako, a pacijentu ne smeteju pri govoru[11,12].

Kukice se ne izrađuju od metala, već od identičnog fleksibilnog materijala, što protezama, pored zavidne retencije, obezbeđuje i lep izgled (slika 2). U cilju postizanja boljeg estetskog učinka,poliamidne proteze mogu sekoristiti u kombinaciji sa skeletiranim protezama.

denture, which gives a more natural look in the patient's mouth. Pigments that are free of cadmium and other metal oxides are used for their dyeing[25].

Since they have low specific weights, they are made in a very thin layer (0.5 mm), so it is easy to get used to wearing them, and the patient is not disturbed when speaking[11,12].

The clasps are not made of metal, but from the same flexible material, which, in addition to enviable retention, gives the dentures a pleasing appearance (Figure 2). In order to achieve a better aesthetic effect, polyamide parts can be used in combination with metal partial dentures.

Slika 2. Transparentnost dentalnih poliamida
Figure 2. Transparency of dental polyamides

Biološka svojstva

Problem upotrebe akrilatnih materijala je i njihovo moguće alergijsko i toksično dejstvo, koje je sve češće, kako kod pacijenata tako i kod medicinskog osoblja koje njime rukuje[26,27]. Kao najčešći uzrok ove pojave navodi se nedovoljna polimerizacija samog materijala i oslobađanje rezidualnog monomera iz proteza izrađenih od akrilata. Kompletna polimerizacija obezbeđuje optimalnu biokompatibilnost poliamidnih proteza, tako da nema alergijskih reakcija.

Mala poroznost poliamidnog materijala sprečava akumulaciju mikroba, posebno kandide[28]. Poliamidni materijal za izradu baze proteze, kada se polira konvencionalnim laboratorijskim tehnikama, postao je glatkiji od akrilata, te se može, sa stanovišta adherentnosti biofilma, smatrati biološki prihvatljivijim[29].

Biological properties

The problem with the use of acrylic materials is their possible allergic and toxic effect, which is increasingly common in both patients and medical staff who handle itthem[26,27]. The most common cause of this phenomenon is insufficient polymerization of the material itself and the release of residual monomer from acrylate dentures. Complete polymerization of polyamide dentures ensures their optimal biocompatibility, and thus there are no allergic reactions.

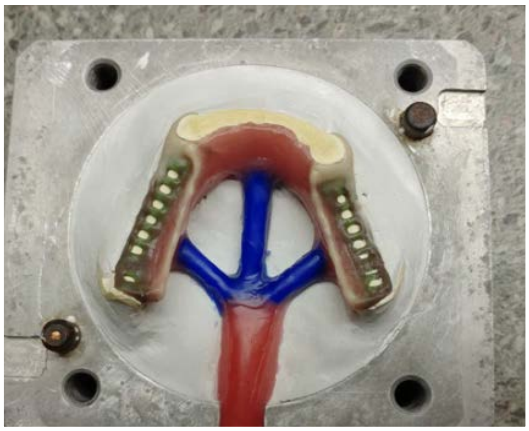
The low porosity of the polyamide material prevents the accumulation of microbes, especially candida[28]. By polishing polyamide materials for making the base of the denture using conventional laboratory techniques, the surface becomes smoother than when applying the same procedure to acrylate dentures, and can, from the point of biofilm adherence, be considered more biologically acceptable[29].

Način izrade poliamidnih proteza

Kliničke faze izrade proteza od poliamida podrazumevaju uzimanje anatomskog otiska i izlivanje radnog modela, izradu skeleta od poliamida, određivanje međuviličnih odnosa, postavu zuba i definitivnu izradu proteze. Razlika je u injekcionom sistemu, odnosno ubrizgavanju materijala u kalup, koji predstavlja negativ buduće nadoknade. Materijal se dobija u vidu solidnih pakovanja, koja se preoblikuju u posebnom sistemu, sa posebnim kivetama. Obrada materijala je laka, a poliranje je identično akrilatnim materijalima. Pojedine faze izrade poliamidnih proteza prikazane su na slikama od 3 do 6.

Methods of fabricating dentures using dental polyamides

The clinical phases of making polyamide dentures include taking an anatomical impression and casting the working model, making a polyamide skeleton, determining intermaxillary relations, tooth placement and definitive denture fabrication. The difference is in the use of an injection system, that is, the injection of the polyamide material into a mold, which represents the negative of the future edentulous compensation.The material is obtained in the form of solid packages that are reshaped in a special system, with the use of special flasks. The processing of the material is easy, and the polishing is identical to acrylic materials. The individual stages of making polyamide dentures are shown in Figures 3 to 6.



Slika 3. Ulaganje voštanog modela poliamidne proteze u kivetu
Figure 3. Insertion of the wax polyamide denture model into a flask

Slika 4. Aparatura za izadu poliamidnih proteza
Figure 4. The apparatus for production of polyamide dentures

Slika 5. Skelet parcijalne polamidne proteze
Figure 5. Skeleton of a partial polyamide denture

Slika 6. Poliamidni skelet i zagrižajni bedemi
Figure 6. Polyamide denture base and occlusal rims

Nedostaci poliamidnih pločastih proteza su gingivalni prenos pritiska žvakanja i loša retencija, ukoliko nema bilateralne podminiranosti vilica ili protetskog ekvatora (priprema zuba krunicama).

Detaljno upoznavanje kliničkih i laboratorijskih faza izrade proteza od poliamida pruža širi dijapazon mogućih izbora u kliničkoj praksi. Da li će i u kolikoj meri fleksibilne proteze zameniti pločaste akrilatne, između ostalog zavisi i od stepena informisanosti o njihovoj nameni i načinu izrade.

Zaključak

Dentalni poliamidi indikovani su za izradu estetskih fleksibilnih parcijalnih proteza, zavidnih mehaničko-fizičnih svojstava, idealnih za primenu kod pacijenata sa alergijom na monomer. Razvoj novih svojstava, kako poliamida , tako i drugih termoplastičnih masa , sigurno će omogućiti nove terapijske indikacije za primenu u terapiji pacijenta sa oštećenim zubima , parcijalnom krezubošću ili totalnom bezubošću.

The disadvantage of polyamide partial dentures is the gingival transmission of masticatory pressure, poor retention if there areno bilateral undercuts of the jaws or the prosthetic equator (restoring certain teeth with crowns).

Detailed introduction to clinical and laboratory stages of polyamides used in prosthodontics, provides a broad range of possible choices in clinical practice. Whether and to what extent flexible dentures will replace acrylic dentures, among other things, depends on the degree of information about their purpose and method of production.

Conclusion

Dental polyamides are indicated for the production of aesthetic flexible partial dentures, with enviable mechanical and physical properties, ideal for use in patients with monomer allergy. The development of new properties, both in polyamide and other thermoplastic materials, will certainly enable new therapeutic indications for use in the treatment of patients with damaged teeth, partial tooth loss or edentulism.

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