

BIOFIZIKA LASERA - II DEO**BIOPHYSICS OF LASERS - PART II***Goran Jovanović, Nikola Burić, Nebojša Krunic*

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Kratak sadržaj

Detaljno je obrađena biologija lasera koja obuhvata interakciju laserskog zračenja sa tkivom i mnogobrojne primarne i sekundarne efekte iz kojih proizilaze terapijski efekti. Navedene su indikacije i kontraindikacije za primenu lasera u stomatologiji, a na kraju rada ukazano je na štetne efekte koji mogu da nastanu prilikom nestručnog rukovanja laserskim aparatom.

Cljučne reči: laser, biofizika, biostimulacija, indikacije, kontraindikacije

Abstract

In this work has been detailed biology of lasers which includes the interaction of laser radiation with tissue and many primary and secondary effects which on the other side cause therapeutic effects. There were mentioned indications and contraindications for laser usage in dentistry, and at the end of the work there were mentioned harmful effects which could appeared by unprofessional usage of laser device.

Key words: laser, biophysics, biostimulation, indications, contraindications

Interakcija sa tkivom

Dejstvo lasera na tkivo zavisi u prvom redu od tehničkih karakteristika lasera i od fiziološko-hemijskog i biološkog stanja tkiva. Pod tehničkim karakteristikama podrazumevamo tip lasera, talasnu dužinu zračenja, frekvenciju impulsa, energiju i gustinu snage zračenja na jedinici površine, širinu laserskog snopa, vrstu režima rada itd.¹ Anatomico-histološka građa, intenzitet cirkulacije, toplotna provodnost, stupanj hidratisanosti, debljina podsluzokožnog i potkožnog tkiva, heterogenost mikrostrukture, pigmentacija, i koeficijent apsorpcije/refleksije su parametri koji spadaju u fiziološka stanja tkiva.²

Parametri koji utiču na distribuciju laserskog zračenja u tkiva su:

Interaction with tissue

The effect of laser on tissue depends at first side on technical characteristics of laser and on physiology-chemical and biologic state of tissue. Under the technical characteristics we mean the type of laser, frequency of radiation, frequency of impulse, energy and density power of radiation on unit of area, width of laser beam, kind of working and so on.¹ Anatomical-histological material, circulation intensity, thermal conduction, stage of hydration, thickness of submucous membrane and subcutaneous tissue, heterogeneous of microstructure, pigmentation and coefficient of absorption/reflection are parameters which belong to physiological state of tissue.²

Parameters which influence on distribution of laser radiation are following:

- a) refleksija - u zavisnosti od ugla delovanja lasersko zračenje se može manje ili više odbijati, pri čemu se jedan deo energije od strane tkiva apsorbira (apsorpcija je bolja ukoliko je tkivo bogatije vodom, bilirubinom, melaninom, karotinom, oksihemoglobinom i hemoglobinom),²
- b) rasejavanje - deo energije koji prodire u tkivo se širi i gubi u okolno tkivo, i
- c) transmisija – lasersko zračenje može da prođe u dublje strukture tkiva na koje se ne želi uticaj.

Biološko dejstvo

1. Primarni efekti

Fotohemijski - stimuliše oslobađanje hemijskih medijatora (serotonin, bradikinin i histamin); ubrzava sintezu vitamina A i D; aktivira sistem DNK i RNK i stimuliše razmnožavanje ćelija; stimuliše pretvaranje ADP u ATP ubrzavajući ćelijski metabolizam; i inhibira sintezu prostaglandina.³⁻⁵

Fotoelektrični - jako električno polje koje se stvara oko laserskih zraka dovodi do normalizacije potencijala ćelijske membrane nervnih vlakana i onemogućava normalno odvijanje procesa depolarizacije (blokira kalijum natrijumovu pumpu i prenos jona natrijuma i hlora s jedne i kalijuma s druge strane, tako da se prekida prenos nervnih impulsa).⁶

Fotoenergetski – stimulacijom pretvaranja ADF u ATP na nivou mitohondrija povećava se intracelularna energija.⁷

2. Sekundarni efekti

Stimulacija ćelijskog metabolizma – ogleđa se u ubrzanoj ćelijskoj razmeni materija; doobi i diferencijaciji ćelija; povećanoj intracelularnoj energiji u obliku ATP i povećanom prilivu kiseonika (posledica pojačane mikrocirkulacije), tako da je stimulirano ćelijsko disanje, kao i unošenje hranljivih i eliminacija toksičnih materija.⁸

Stimulacija mikrocirkulacije – stimuliše oslobađanje histamina koji parališe prekapilarni sfinkter što za posledicu ima arteriolarnu dilataciju.⁹ Ovaj efekat se ne zasniva na lokalnom povećanju temperature tkiva. Minimalno povećanje temperature tkiva, do fizioloških granica, posledica je pojačanog ćelijskog me-

- a) reflection – in dependence on working angle, laser radiation can be less or more reflected, when one part of energy has been absorbed by tissue (absorption is better if tissue is richer with water, bilirubine, melanin, carotene, oxyhemoglobin and hemoglobin)²,
- b) diffusion – one part of energy which penetrates in tissue has been amplified and disappeared at tissue in surrounding, and
- c) transmission – laser radiation can pass through in deeper tissue structure on which we don't want to have influence.

Biological effect

1. Primary effects

Photochemical – it stimulates release of chemical mediators (serotonin, bradikinin and histamine); it accelerates synthesis of vitamin A and D; activate DNK and RNK system and stimulates multiplication of cells; stimulates ADP changing in ATP with acceleration of cells metabolism; and it inhibits synthesis of prostaglandin.³⁻⁵

Photoelectric – strong electric field which appeared round laser rays can cause the normalization of potential of nerve fiber cell membrane and disable normal running of depolarization process (it blocks potassium sodium pump and transfer of sodium and chlorine, on one side, and potassium, on the other hand, so the transfer of nerve impulses have been interrupted).⁶

Photoenergetic - by stimulation of ADF changing in ATP on mitochondria level, intracellular energy has been increased.⁷

2. Secondary effects

Stimulation of cells metabolism – it is shown in accelerate material exchange of cells; fission and differentiation of cells; increased intracellular energy in state of ATP and increased influx of oxygen (consequence of increased microcirculation), so the cells aspiration as well as the loading of nourishing material and elimination of toxic material have been stimulated.⁸

Stimulation of microcirculation – it stimulates release of histamine which paralyzes over capillary sphincters. The consequence is arteriolar dilatation.⁹ This effect has not been based on local increase of tissue temperature. Minimal increase of tissue temperature, until physical limits, is consequence of increased cells me-

tabolizma i vazodilatacije krvnih sudova. Prednost lasera u odnosu na druge fizikalne metode (infra-crveno, ultra-violetno zračenje, diatermija itd.) jeste da svoj terapijski efekat ostvaruje bez termičkog dejstva, te se može slobodno koristiti u inficiranom tkivu.

3. Terapijski efekti

Analgetički efekat - nastaje kao posledica fotoelektričnog dejstva i stabilizacije ćelijske membrane neurona (blokada prenosa nervnih impulsa); brža resorpcija zapaljenjskog eksudata smanjuje pritisak izlivenne tečnosti na periferne nervne završetke; aktivna vazodilatacija stvara uslove za bolju ishranu i regeneraciju oštećenih nerava; dok povećana produkcija endorfina u likvoru i serumu hiperpolarizuje ćelijske membrane i izaziva centralnu i perifernu akciju na neurohumoralne hemijske medijatore i sintezu endogenih peptida, što takođe ima analgetičko dejstvo.¹⁰⁻¹²

Antiinflamatorni efekat - stimuliše fagocitnu aktivnost neutrofilnih leukocita, mikro- i makrofaga; mitotsku aktivnost makrofaga; a sveukupno stimuliše celularni i humoralni imunitet. Efekta lasera na zapaljenje sastoji se i u stimulaciji nespecifične humoralne odbrane i porastu sinteze komplemenata, lizozoma i interferona.⁸ Isto tako, stimulacijom makrofagalnog sistema aktivira se i imunokompetentni sistem (T i B limfociti) sa kojim nastupa specifična imunološka odbrana.⁸

Antiedematozni efekat - ubrzava regeneraciju limfnih i venskih sudova i smanjuje intrakapilarni pritisak, izazivajući bržu eliminaciju (apsorpciju) izlivenne tečnosti.¹³

Biostimulativni efekat - stimuliše rast i reprodukciju fibroblasta i osteoblasta, sintezu kolagenih vlakana, regeneraciju nervnih, endotelnih i epitelnih ćelija, mitotsku aktivnost makrofaga i enzimsku aktivnost ćelija.¹³

Indikacije za primenu lasera velike snage

- precizno sečenje i koagulacija tkiva,
- biopsija i uklanjanja malignih i benignih tumorskih lezija,
- hirurške intervencije na temporomandibularnom zglobu,
- preprotetske hirurške procedure,

tabolism and vasodilatation of blood vessels. The advantage of lasers in comparison with the other physical methods (infrared, ultraviolet radiation, diathermia, etc.) is that it achieves its therapeutic effect without thermal effect, so it can be used without doubt in infected tissue.

3. Therapeutic effects

Analgetic effect – it appears as consequence of photoelectrical action and stabilization of cells membrane of neurons (blockade of nerve impulses transfer); faster resorption of inflammatory exudates reduce pressure of molten liquid on periphery nerve upshot; active vasodilatation makes conditions for better nourishment and regeneration of disabled nerves; while increased production of endorphin in liquor and serum hyperpolarize cell membrane and generate central and periphery action on neurohumoral chemical mediators and synthesis of endogenous peptides, which also has analgetic effect.¹⁰⁻¹²

Anti-inflammatory effect – it stimulates phagocyte activity of neutrophil leucocytes, micro- and macrophages; mitotic activity of macrophages; and it altogether stimulates cellular and humoral immunity. Laser effect on inflammation consists also of stimulation nonspecific humoral defense and increase of complements synthesis, lisosomes and interpherones.⁸ Likewise, by stimulation of macrophage system there has been activated also immune competent system (T and B lymphocytes) with which arrive specific immune defense.⁸

Anti edema effect – it accelerates regeneration of lymphatic and venous vessels and decreases intra capillary pressure, provoking faster elimination (absorption) of molten liquid.¹³

Biostimulative effect – it stimulates growing and reproduction of osteoblastes, synthesis of collagen fiber, regeneration of nervous, endothelial and epithelial cells, mitotic activity of macrophages and enzyme activity of cells.¹³

Indications for the usage of great power lasers

- precisely cutting and tissue coagulation,
- biopsy and removing of malignant and benign tumor lesions,
- surgical interventions on temporomandibular joint,
- prothetic surgical procedures,

- uklanjanje infektivnih lezija i hemangioma,
- gingivektomija i gingivoplastika,
- implantologija,
- terapiji mnogih parodontalnih oboljenja,
- kariologija - sečenje tvrdih zubnih tkiva i uklanjanje karijesa,
- ispitivanje i polimerizacija materijala za restauraciju,
- endodoncija - sterilizacija kanala, i
- izbeljivanje zuba.

- removal of infective lesions and hemangiomas,
- gingivectomy and gingivoplastic,
- implantology,
- therapy of many parodontic diseases,
- cariology - cutting of hard teeth tissues and removal of caries,
- inspection and polymerisation of materials for restoration,
- endodontology - canals sterilization, and
- teeth whitening.

Indikacije za primenu lasera male snage

- terapija alveolitisa i drugih bolova u hirurgiji,
- pospešuje zaraščivanje rana,
- smanjuje stvaranja fibroznog tkiva i ožiljaka,
- smanjuje postoperativni bol, edem i trizmus,
- ispitivanje vitaliteta zuba,
- terapija hroničnih i neuralgičnih bolova,
- kariologija i endodoncija,
- dijagnostika i terapija parodontalnih oboljenja (gingivitis, afte, herpesne lezije, lihen planus), i
- terapija hipersenzitivnog dentina.

Indications for low power lasers usage

- therapy of alveolitis and other pains in surgery,
- it improves overrunning of wounds,
- reduces appearance of tissue fibrosis and scars,
- reduces postoperative pain, edema and trismus,
- inspection of teeth vitality,
- therapy of chronic and neuralgic pains,
- cariology and endodontology,
- diagnosis and therapy of parodontic diseases (gingivitis, afthes, herpes lesions, lihen planus), and
- therapy of hypersensitiv dentine.

Štetni efekti

Za razliku od lasera velike snage, koji nekvalifikovanom i neadekvatnom upotrebom zbog izrazitog termičkog dejstva mogu izazvati velika tkivna razaranja, laseri male snage gotovo da nemaju štetnih uticaja. S obzirom da i pri prekoračenju doze laserski zraci ne povećavaju znatnije temperaturu tkiva (najčešće ostaje u fiziološkim granicama) može se zaključiti da ne mogu izazvati termička oštećenja.

Međutim, reflektujući se od ravnih metalnih površina (ogledalce, ekarter) laserski zraci se odbijaju i mogu oštetiti vid. Povrede nastaju tako što refrakcioni sistem oka fokusira laserske zrake na dno oka, tako da se njihovo dejstvo može pojačati i stotinu puta.⁴ Zaštita od ovakvih efekata obuhvata upoznavanje osoblja sa štetnim dejstvom laserskih zraka, stručno i oprezno rukovanje laserskim aparatom i obavezna upotreba zaštitnih naočara.

Harmful effects

In contrast to great power lasers which can cause serious destruction of cells by unqualified and inadequate usage, low power lasers doesn't have anything harmful effects. Knowing the fact that also with overdosage, laser rays don't increase tissue temperature considerably (most often it is in physical limits), there can be concluded that laser rays can not produce thermal damage.

However, laser rays are reflected from flat metal surfaces (mirror, ekarter) and they can damage sense of sight. Injuries appear because refractive eye system focuses laser rays to the bottom of eye, so its effect can be increased even for hundred time.⁴ Defense of such effects includes presentation of the laser ray harmful effects to the personnel, competent and careful managing with laser device and compulsory usage of glasses.

Zaključak

Razvoj savremene stomatologije prate brojne inovacije a među prvima od njih je primena lasera. Zahvaljujući velikom broju biostimulativnih efekata, laseri male snage se već uveliko koriste u stomatološkoj praksi, dok laseri velike snage sve češće primenu nalaze ne samo u oralnoj i maksilofacijalnoj hirurgiji već i u drugim oblastima stomatološke delatnosti.

Conclusion

Development of contemporary dentistry has been followed by numerous inovations and first of them is usage of lasers. Thanks to great number of biostimulative effects lasers of low power have been used for a long time in practice of dentistry, while lasers of great power have been used more often not only in oral and maxillofacial surgery but in other fields of dentistry.

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