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Application of superluminous clusters in treatment of myofascial disorders

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Приложение на суперлуминисцентни клъстери при лечението на миофасциални заболявания

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Summary

The aim of this study is to estimate pain intensity reduction using superluminous diodes (SLD) in combination with laser phototherapy in three of the most common myogenic disorders - local myalgia, myofascial pain and myofascial pain with referral. Material and methods: A total of 62 patients with temporomandibular disorders were assessed, 28 of whom were diagnosed with pain on palpation of the masticatory and neck muscles. Diagnosis and grouping of patients were performed using DC/TMD methodology. Spot laser and SLD irradiation of large areas was applied to the affected muscles. Patients were evaluated at the start of treatment, and after the 6th session of phototherapy. The pain intensity scores were measured according to the Visual Analogue Scale (VAS). Results: Our results show statistically (t- test) manifested pain reduction for local myalgia group (7 cases, p = 0, 000905), myofascial pain (11 cases, p = 0, 001789) and myofascial pain with referral (11 cases, p = 0.000284). Conclusion: The use of SLDs cluster devices significantly contributes to the reduction of pain in all types of myalgia, due to the pro-oxidative effect of photons with 633 nm wavelength, a large area of exposure, sufficient tissue penetration, and some positive warming thermal impact of the SLD clusters.

Key words: *DC/TMD, Myofascial pain disorders, Superluminous clusters*

Резюме

Целта на това изследване е да се оцени намаляването на интензитета на болката с помощта на суперлуминисцентни диоди (SLD) в комбинация с лазерна фототерапия при три от най-често срещаните миогенни разстройства – локална миалгия, миофасциална болка и миофасциална болка с отразяване. Материал и методи: Бяха обследвани общо 62 пациенти с темпоромандибуларни заболявания, 28 от които бяха диагностицирани с болка при палпация на дъвкателните и шийните мускули. Диагностиката и групирането на пациентите се извършваше по DC/TMD методология. На засегнатите мускули се приложи точково лазерно и SLD облъчване на големи площи. Интензивността на болката беше измерена чрез визуалната аналогова скала (VAS) в началото на лечението и след 6-тата сесия на фототерапия. Резултати: Резултатите от изследването показват статистически (t-тест) значимо намаляване на болката при всички групи пациенти: с локална миалгия (7 случая, p = 0, 000905), с миофасциална болка

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(11 случая, p = 0, 001789) и с миофасциална болка с отразяване (11 случая, p = 0,000284). Заключение: Използването на клъстерни устройства (SLD) значително допринася за намаляване на болката при всички видове миалгии, което се свързва с прооксидативния ефект на фотоните с дължина на вълната 633 nm, голяма площ на експозиция на SLD устройствата, достатъчно проникване в тъканите и известно положително затоплящо топлинно въздействие на клъстерите.

Ключови думи: *DC/TMD, миофасциални болкови разстройства, SLD клъстери*

Introduction

The theory of generating pathologically enhanced excitability (capacity of nerves and other tissues to generate and sometimes propagate action potentials, i.e., signals that serve to control intracellular processes, such as muscle contraction, synaptic transmitter release or hormone secretion) is based on the fact that a focus of pathological excitability is formed in masticatory muscles in the form of trigger points (TP), painful on palpation. A TP is a local compaction of a muscle, which can have various sizes, configurations, lengths, and consistencies [1, 2].

Formation of myofascial trigger zones is based on neuromuscular dysfunction of the end plates of extrafusal muscle fibers with local intramuscular hypoperfusion and subsequent hypoxia. Structural abnormalities in the taut band including altered myofibrils, divergence of myofilaments and Z-lines with uneven distribution of mitochondria and appearance of autophagosomes in the muscle compression zone are observed in patients with myofascial pain. These disorders may be result of inadequate, depleting physical load on the muscle in spasmodic condition with local hypoxia or ischemia.

Muscle spasm is the basis for the development of dysfunctional syndrome. It arises from excessive stretching, contraction and muscle fatigue. In the first stage, residual tension occurs in the muscle, followed by stable local hypertonicity. The biochemical basis for the formation of muscle seals is an excess of calcium with a deficiency of high-energy compounds, which causes an increase in the contractility of muscle fibers and a decrease in blood flow in them. In the masticatory muscles with such dysfunction, there are foci of contracture, areas of overstretching and physiological disturbances in the contraction process [3, 4, 6].

Travell and Simons [1] describe in detail the synergism of the masticatory muscles in the movements of the lower jaw. This functional synergism may explain the occurrence of multiple painful points in distant, not directly related to the temporomandibular joint muscles [5].

However, clinicians with extensive experience know that the detection of pain in distant muscles sometimes occurs just through gentle, light palpation over the muscle, not necessarily at a specific trigger point. Also, the intensity of pain in these distant areas is disproportionately higher compared to the pain intensity in the masticatory muscles which are directly involved in condylar and joint dysfunctions of any nature.

This means that our knowledge needs to be supplemented with a recent concept on fascial involvement in the pathogenesis of the myofascial pain spread. Fasciae are known to be richly innervated with small-diameter afferent fibers that can transmit nociceptive signals, especially in the presence of inflammation. Fasciae coordinate biochemical signals and are an important communication system saturated with receptors and free nerve endings – more than 80% of free nerve endings are concentrated in the fascia [3].

Superluminous light emitting diodes are similar to laser diodes, in that they contain an electrically-driven p-n junction, but lack optical feedback so only spontaneous emission of radiation is achieved. [1]. SLD generated photons may penetrate to a depth of 2 cm., which makes them suitable for irradiation of facial and cervical fasciae. An efficient absorption of light energy at a cellular level and a number of photochemical reactions are initiated, expressed in increase of tissue metabolism, pain reduction, stimulation of the vascular, immune and lymphatic systems with a cumulative effect in the cells. A particularly important effect of phototherapy is the stimulation of collagen synthesis, which supports the reparative processes in the fascia [16].

SLD's produce incoherent light. However, it has been shown that the temporal coherence of a laser beam is mostly lost by the time the beam has passed through the first 1mm of tissue and that the property of coherence is of no significance at cellular level. Karu [14] has shown that coherence is not of importance when considering photo-biological reactions: "Coherent properties of laser light are not important when cellular monolayers, thin layers of cell suspension as well as thin layers of tissue surface, are irradiated. In these cases, the coherent and non-coherent light (i.e., both lasers and LED's) with the same wavelength, intensity and dose provides the same biological response."

Another important feature of SLDs is their safety. Coherent light beams can cause retinal damage so safety goggles should be worn by the treating practitioner and the patient whereas non-coherent light from SLDs do not cause retinal damage [8, 9, 10, 15, 17, 18].

Aim of the study

The aim of this study is to estimate pain intensity reduction using superluminous diodes (SLD) in combination with laser phototherapy in three of the most common myogenic disorders – local myalgia, myofascial pain and myofascial pain with referral.

Material and methods

A total of 62 patients with temporomandibular disorders were assessed, 28 of whom were diagnosed with pain on palpation of the masticatory and neck muscles. Diagnosing and grouping of the patients were performed by Axis I examination protocol of DC/TMD [11]. 633 nm SLDs irradiated the complete muscle area, supplemented by 785 nm spot laser sessions at the verified trigger points. The SLD cluster is composed of 49 visible red (633 nm) and infrared (880 nm) diodes which deliver up to 50 0mW energy to the target sites. The mean SLD dose was 12.25 J per session. Patients were evaluated at the start of the treatment, and after the 6th session of phototherapy. The pain intensity scores were measured according to Visual Analogue Scale (VAS). T-test and STATISTICA software were used for statistical analysis.

Fig. 1. *Clinical application of SLD clustres*

Results

The most statistically manifested pain reduction is found for local myalgia group (7 cases, p = 0, 000905), followed by myofascial pain group (11 cases, p = 0, 001789) and myofascial pain with referral group (11 cases, p = 0.000284). The results show that all types of myalgia are effectively influenced by low doses of red light from SLD clusters. The reduction in masticatory muscle pain can be as high as 90 percent from baseline, whether the pain affects those muscles unilaterally or bilaterally.

Table 1. *Pain reduction in VAS scores and t-test for three groups myogenic disorders according to DC/TMD classification*

Diagnosis according to DC/TMD	Pain VAS scores	SD	N	t	p
Local myalgia before treatment	0,935	2,102			
Local myalgia after treatment	0,032	0,254	7	3,48	0,000905
Myofascial pain before treatment	1,774	4,282			
Myofascial pain after treatment	0,274	1,369	11	3,26	0,001789
Myofascial pain with referral before treatment	2,274	4,763			
Myofascial pain with referral after treatment	0,322	1,036	11	3,85	0,000284

Table 2. *Pain reduction in VAS scores and t-test for masseter and temporalis muscles*

Organ	Pain VAS scores	SD	N	t	p	Pain reduction
m.temporalis unilateral,before treatment	6,2	1,3				
m.temporalis unilateral,after treatment	2,2	2,7	5	3,81	0,018878	64,51%
m.masseter unilateral,before treatment	5,346	1,4				
m.masseter unilateral,after treatment	0,423	0,8	26	15,9	0,000001	92,08%
m.masseter bilateral, before treatment	5,692	1,6				
m.masseter bilateral, after treatment	0,615	1,3	13	10,43	0,000001	89,07%

Discussion

The current results show the effectiveness of SLD diodes in the treatment of the external group of masticatory muscles. One possible explanation for the highly positive clinical effect of SLD diodes is that mechanisms of action of red and near-infrared radiation are related to the activation of electron transfer along the respiratory chain of mitochondria. At the same time, the activation of tissue respiration, together with an increase in the intensity of metabolism all lead to an extremely high accumulation of reactive oxygen and radical intermediates. Photosensitive chromophores and other elements in the cell absorb light energy and initiate a series of important photochemical reactions, such as increased production of nitric oxide, singlet oxygen and adenosine triphosphate (ATP), as well as changes in cell membrane permeability. Electron transfer is of paramount importance for the respiratory chain in mitochondria, where the major chromophores involved in photochemical reactions are located. Stimulation of the Krebs cycle initiates the production of ATP, which provides additional energy and speeds up metabolism. Light energy and the biochemical reactions associated with its assimilation lead to the normalization of cellular functions [12, 13, 15, 16].

It is also important to be noted that the heat generated by the SLD cluster can reach 400 C at skin contact after 5 minutes of treatment; the dose of 8 J/cm^2 in continuous mode is realized within 300 seconds, therefore, the positive thermal effect of the SLD clusters should also be taken into account. Therefore, local SLD sessions may ensure improvement of blood flow within the myofascial trigger zone.

Conclusion

The present study shows that SLDs cluster devices significantly contribute to the reduction of pain in all types of myalgia, due to the prooxidative effect of photons with 633 nm wavelength, a large area of exposure, sufficient tissue penetration, and some positive warming thermal impact of the SLD clusters.

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