Acta of Bioengineering and Biomechanics
Vol. 17, No. 4, 2015

Original paper
DOI: 10.5277/ABB-00276-2014-02

The influence of low-frequency variable magnetic fields in reducing pain experience after dental implant treatment

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The paper presents the evaluation of analgesic effect or magnetostimulation and magnetoledtherapy after implantation treatment. The study was conducted on 3 groups (Z applicator, IR applicator and conventional drug therapy) of 10 patients each of whom underwent a single implantation. Magnetostimulation was carried out using Viofor JPS Delux equipment. The patients were exposed to magnetic field for approx. 15 minutes before the treatment and during the visit after 6 hours after the implantation procedure. Pain perception of patients was recorded on the Visual Analogue Scale (VAS). Results: the most intense pain was reported in the control group. The least intense pain appeared in the group with Z applicator. Patients using Z and IR applicators took analgesics less frequently and used much weaker analgesics than the control group. Pain perceived in the first group was between 0 and 2, while in the second group – between 2 and 3, and in the control group – between 3 and 5 in VAS scale. Magnetostimulation reduces patient's demand for analgesics after implantation procedures and yielded better effects in reduction of pain in comparison with magnetostimulation with LED therapy.

Key words: *implantology, magnetoledtherapy, magnetostimulation*

1. Introduction

Pain is an unpleasant sensorial and emotional experience associated with actual or potential tissue damage or described in terms of such damage [22]. Pain is also a subjective mental experience that can be divided into the following categories in terms of its duration: acute pain, i.e., post-operative or post-traumatic pain, pain related to medical procedures, lasting less than 3 months, as well as the pain having a warning and protective function [22], [12]. Chronic pain, lasting more than 3 months, requiring multidisciplinary therapy and retained pain, appearing usually as a consequence of poor treatment of acute pain [7]. The process of triggering pain sensation is called nociception and consists of three stages: transduction, transmission and perception [28]. Receptors responsible for reception of mechanical, thermal and chemical pain stimuli are called nociceptors and the nociception process of triggering pain consists of transduction, transmission and perception [7], [28]. Those specialized receptors have been classified on the basis of their anatomic and physiological properties [29]. They can be divided into two groups. First A-δ receptors in thin mineralized fibers are responsible for the experience of acute, localized pain [29]. They receive mechanical and thermal stimuli and are able to transmit a signal at a speed of 5–20 m/s [17]. The second group of nociceptors are the so called "silent C-receptors" that are not sensitive to mechanical or thermal stimuli above the threshold level. Such receptors are activated in damaged or inflamed tissues. They accompany the phenomenon of spatial summation and sensitization of

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Received: December 31st, 2014
Accepted for publication: February 3rd, 2015

receptors at the central level [17], [29]. Because of high innervation of the stomatognathic system, pain sensations are probably the most common symptoms encountered by dentists during their professional practice. Application of implants and surgical techniques allows for improvement of the prosthetic area quality, as well as stabilization and retention of prosthetic restorations [23]. Unfortunately, such invasive procedures are associated with pain. Elimination of pain during and after implantation treatment, for example, with the use of non-steroid anti-inflammatory drugs, is one of the main tasks in pre- and postoperative treatment of patients [23]. There are also alternative forms of pain management therapy with equipment used in physical medicine. Those include Light Emitting Diodes (LEDs) emitting monochromatic, incoherent red, infrared or red-infrared light. In the solar spectrum, infrared radiation is directly under the visible red light [17]. The depth of penetration of infrared radiation into the skin depends on its wavelength; a shorter wave shows the deepest penetration [17]. Biological action of infrared radiation is connected with slight increase of tissue temperature as a result of increase in kinetic energy of tissue particles. This can cause local and distant tissue congestion, as well as affect internal organs, causing local increase of metabolic rate. This phenomenon can have analgesic effect, as well as anti-inflammatory effect, which can help patients suffering from degenerative disc disease, fracture, overload, trauma and degenerative joint disease [33]. Devices emitting infrared radiation have analgesic effect helpful in various forms of neuralgia, as well as anti-inflammatory effect, which can help patients suffering from degenerative disc disease, fracture, overload, trauma and degenerative joint disease [33], [41]. Low-frequency variable magnetic fields in the form of magnetostimulation have similar beneficial effects. During such treatment, the production of endogenous opioid β-endorphins in human body increases [30]. Low-frequency variable magnetic fields (0.1–100 Hz) can modify the endogenous opioid system and affect the exogenous supply of opiates and the reaction of specific opioid receptors to low-frequency magnetic field can be varied: decreased activity of μ and κ receptor antagonists, inhibition of receptor activity and no effects on σ receptor [6], [27], [15]. The mechanism of magnetic field action is also connected with modulation of calcium channels in cell membranes taking into consideration the distribution of calcium ions [30]. There are many methods used to determine pain intensity based on subjective assessment of patient's feelings. Their main goal is to determine the level of pain intensity and the effectiveness of the pain treatment used [30], [35]. The most common are visual scales, the most popular being the Visual Analogue Scale (VAS). Using a 10 cm long ruler, the intensity of the pain is assessed, where "0" means "no pain and "10" means the "worst pain imaginable" [10]. The variant used in children is The Wong-Baker Faces Pain Rating Scale, presenting various facial expressions for different pain intensity. Verbal scales assessing pain in a descriptive way are also used. In such scales, patients can describe their pain using three four grades: no pain, mild pain, moderate pain, severe pain and unbearable pain [34]. The available literature contains comprehensive questionnaires on pain assessment to analyze specific parameters, e.g., Laitinen's or Melzacka-McGill's questionnaire [28], [10], [34], [38], [1]. An instrument called dolorimeter can also be helpful in assessment of pain intensity. The device consists of a movable part pressed against specific body parts and a special meter measuring the pressure force. It is very helpful in diagnostics of fibromyalgia as it can precisely calculate the pressure force on a specific painful area characteristic of such disease [11]. The aim of the study was to estimate the effect of magnetostimulation or/and magnetoledtherapy to reduce pain in patients after implantation treatment.

2. Materials and methods

The study group evaluated were patients aged 31–52 years. The mean age was 41.5 years. In order to preserve the conditions of homogeneity for the accepted experimental model, the research was limited to cases of implantation of a single dental implant in the maxilla or mandible. For research 30 patients were qualified. Inclusion criteria were: (a) written consent to participate in the study, and patients without identified hot spots in the mouth. Exclusion criteria were the diseases that prevent execution of implant surgery, smoking tobacco, chronic use of drugs, lack of consent for the test to participate in the study, outbreaks of inflammation in the mouth, pregnancy, active cancer, active pulmonary tuberculosis, bleeding from the gastrointestinal tract, severe infections of viral, bacterial and fungal, the presence of electronic implants (eg., cardiac pacemaker) and conditions after organ transplants. The occurrence of pain sensation after dental implantation is always subjective. Patients undergoing research were informed of the research methods used, their indications and contraindications. To the study were qualified patients with good general health status on the basis of clinical interview. Patients qualified for the study were interviewed and underwent the general and dental intraoral examination, followed by oral examination and checking the status of temporomandibular joints and masticatory muscles. A necessary condition for entering treatment and research was the signing of a written declaration with the patient's consent for implantation and in scheduled study. Such consent was obtained after having described to patient and discussed with him the course of a surgical procedure, the research and the type of prosthetic reconstruction, which can be applied after the end of the process of osseointegration. In the examined and approved patients there were administered Camlog implants with a length of 11 or 13 mm and a diameter of 3.8 or 4.3 mm. The examined person was qualified when during one treatment it was planned to embed only one implant, in good bone conditions that do not require augmentation procedures prior to or during the surgery. An hour before the treatment the patient received one tablet of 600 mg of clindamycin, and then the same dose 6 hours after the treatment in the context of short-term prophylaxis of endocarditis. Patients commissioned to preventive painkillers were to choose depending on the subjective experience of pain: Ketonal Forte 100 mg of recommended to take 1–2 tablets per day, up to 200 mg per day, or alternatively, in the case of low intensity pain Ibuprofen 200 mg, with the recommendation of 1–2 tablets once every 4–6 hours. The patient taking medicaments had to report to control visit. The surgical procedure was performed under local anesthesia, giving two ampoules of 1.8 ml of mepivacaine hydrochloride. Cutting was conducted with a 12C or 15B blade at the top of the alveolar part of the mandible in place of tooth loss, saving gingival papillae adjacent to teeth and, additional vertical relief cuts were made if necessary. Preparative mucoperiosteum flap took place in a frugal if possible. Then the prepared osteotomy was conducted with cooled physiological saline solution from a set of surgical milling cutters Camlog not exceeding several tens of rotations per minute, in such a way as to obtain a good primary stability, which was evaluated by measuring the peak torque during insertion of the implant using a torque wrench. The average value of the torque was about 35 Ncm. In all the cases studied the locking screw was used, which was supplied by manufacturer in a sterile packaging together with the implant. The wound treatment facilities were supplied with two mattress seams and, if necessary, knots using thread with a thickness of 4-0 Vicryl Plus Ethicon. Immediately after the treatment cooling dressing was applied for about two hours; the patient was provided with written indications and asked to come to the first and another measurement of pain sensation after relief of local anesthetics, that is, after 6 hours and 24 hours after surgery. The study was conducted on a group of 30 patients who had undergone single implantation procedure. Magnetostimulation was carried out using Viofor JPS Delux (Med&Life, Komorów) device, emitting variable magnetic field. The patients were randomly divided into three groups, 10 patients in each group. In the first group, a magnetostimulation with spot Z applicator was used. In the second group, the IR magnetic-light applicator of infrared wavelength 855 nm was used and the control group was subjected to conventional drug therapy using non-steroid anti-inflammatory drugs. The magnetic field mode was M1P3 with intensity level of 12; for both applicators, the user could choose from three programs P1, P2, P3 and three application methods M1, M2, M3 as well as thirteen intensity levels (from 0.5 to 12). The patients were subjected to magnetic field for 15 minutes before the procedure and during a follow-up visit after 6 hours after the implantation procedure. For the purposes of the study, a special questionnaire was prepared to record patients' pain perception on the basis of Visual Analogue Scale (VAS). The questionnaire consisted of general and specific information. The general questions included information related to age and sex of patient, location of implant treatment surgery and the type of anesthesia. Detailed part of the questionnaire contained 4 questions related to effects of magnetic stimulation or magnetledtherapy: 1. Pain perceived during administration of anesthetic, 2. Pain perceived by patient during implantation procedure, 3. Pain perceived by patients within 6 hours after the procedure, 4. Pain perceived by patients within the first 24 hours following the procedure. Each of the detailed questions had a VAS scale. Patient was using a 10 cm long ruler, the intensity of the pain was assessed, where "0" means "no pain and "10" means the "worst pain imaginable". An additional question was posed if the patient was taking medicaments.

In order to verify the hypothesis concerning dependence or independence of nominal variables, χ^2-Pearson's test was preformed. Yantes' correction was used because of the small size of the study group. Calculations were made for the assumed significance level of $\alpha = 0.05$ using Statistica 10 PL software by StatSoft. Correlation between the variables was verified using V-Cramer's correlation coefficient. The results were then interpreted using J. Guilford's scale.

3. Results

The first analyzed parameter was the assessment of pain perception after application of an anesthetic. There were no statistically significant differences in the evaluation of pain in patients subjected to variable magnetic fields (Z and IR applicators) and the control group. No effect on pain perception during application of the anesthetic can result from the fact that the period of application was short and the number of patients in the group was small. Moreover, the V-Cramer's coefficient points to a moderate correlation between the variables presented in Table 1. The most commonly obtained pain intensity level in all groups was 3 according to VAS scale (Fig. 1). At the second stage, patients' pain perception during implantation procedure was assessed in relation to the groups of respondents. The calculated value of p coefficient ($p = 0.01$) proved a between the variables. Therefore, the fact of being in statistically significant correlation a specific group did affect patients' pain perception during the procedure. This hypothesis is confirmed by a high value of V-Cramer's correlation coefficient ($V = 0.55$). According to the second figure, the most intense pain during the procedure was reported by respondents from the control group. Two patients reported pain at the level of 4 and 6 patients at the level of 3. The least intense pain sensations appeared in the group with Z applicator (Fig. 2). Four patients from the control group reported level 6 of pain, other four patients – at level 5 in comparison with patients subjected to variable magnetic fields using Z applicator, where the maximum value in VAS scale was 2 (Fig. 3). Moreover, there is a very close correlation between the variables ($V = 0.87$). Another analyzed parameter was the use of analgesics by respondents. In the group of patients treated only with the magnetic field applicator Z, one patient ingested 1 tablet of ibuprofen 200 mg. In the second group (IR applicator) 5 patients took 1 tablet of ibuprofen and one patient ingested one tablet of Ketonal Forte 200 mg. In the control group 8, patients used 1 tablet of Ketonal forte 200 mg while 2 people took one 200 mg tablet of Ibuprofen. It was observed that various study groups took various amounts of analgesics. Figure 4 shows that patients who underwent variable magnetic field therapy using Z and IR applicator took analgesics less frequently. The first and the second group of respondents used much weaker analgesics than the control group (Fig. 4). Moreover, there was a high correlation between the variables ($V = 0.60$). The last analyzed parameters that appeared to be statistically significant were patients' feelings within the first 24 hours following the procedure, as the calculated value of p coefficient ($p \leq 0.01$) is lower than the assumed

Table 1. Values of χ^2-Pearson's statistics and V-Cramer's coefficient

	χ^2	p	V-Cramer
Pain perceived during administration of anesthetic	8.99	0.06	0.39
Pain perceived by patient during implantation procedure	17.87	0.01	0.55
Pain perceived by patients in 6 hours after the procedure	45.36	0.00	0.87
Intake of analgesics	10.83	0.00	0.60
Pain perceived by patients within the first 24 hours following the procedure	46.20	0.00	0.88

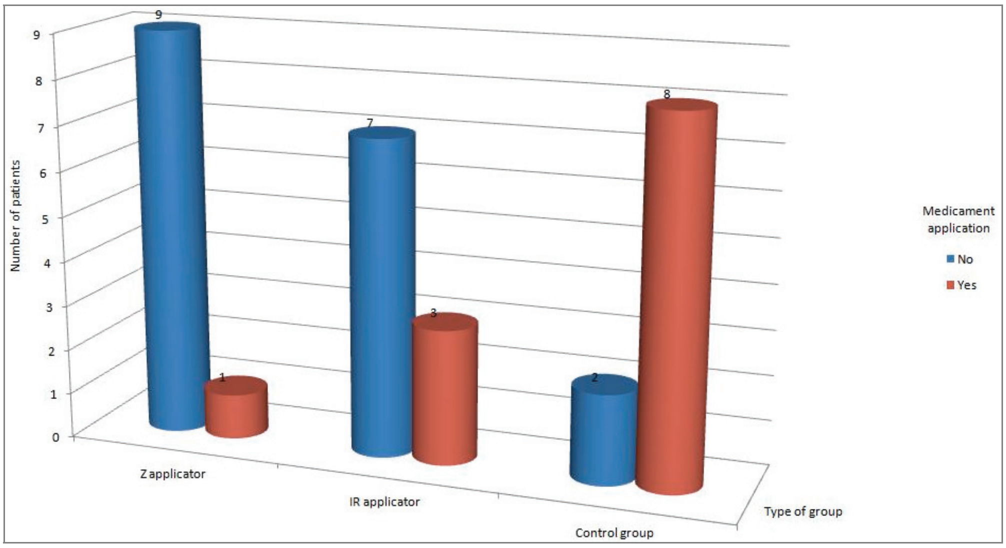

Fig. 1. Pain perceived by the analyzed groups of respondents during administration of anesthetic

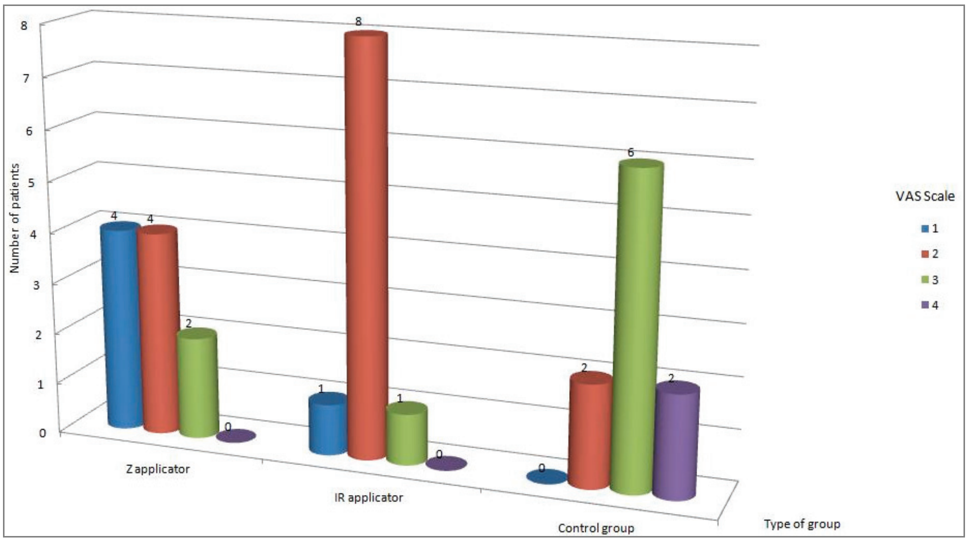

Fig. 2. Pain perceived by specific groups of respondents during implantation procedure

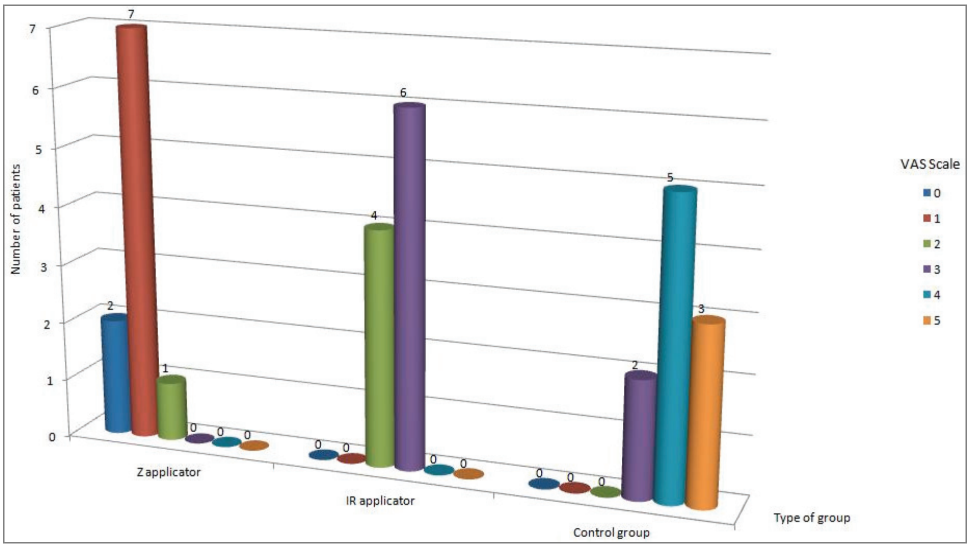

Fig. 3. Pain after 6 hours following the procedure as perceived by the study groups

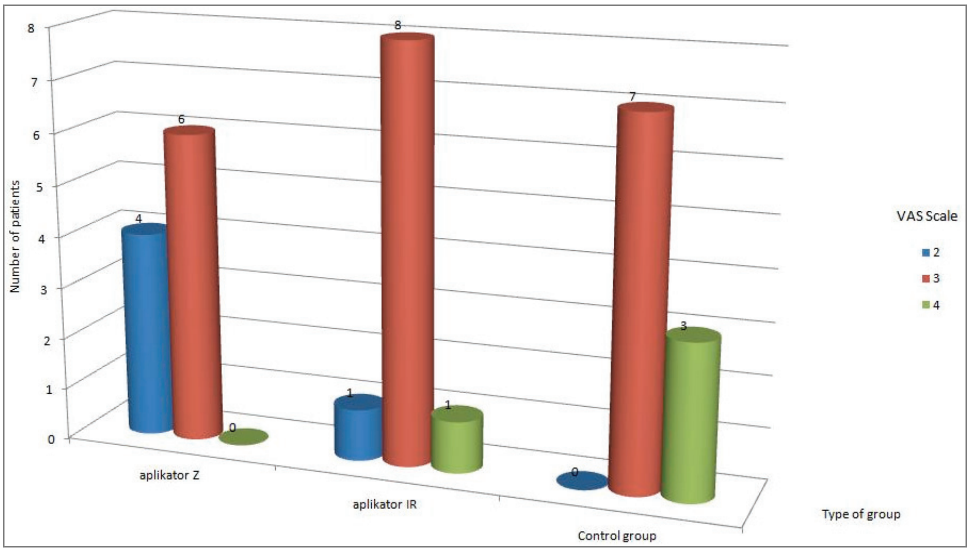

Fig. 4. Intake of analgesics by the following groups of patients: Z applicator, IR applicator, control group

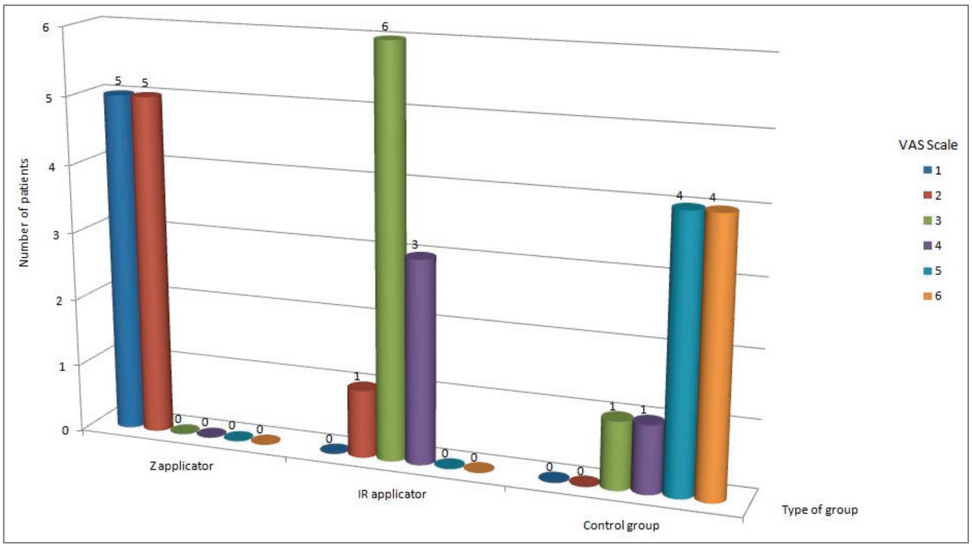

Fig. 5. Pain perceived by the analyzed population after the first 24 hours following the procedure

significance level. The calculated value of *V*-Cramer's coefficient shows a close correlation between the variables ($V = 0.88$). According to VAS scale, pain perceived in the first group was between 0 and 2, in the second group – between 2 and 3 and in the control group – between 3 and 5 in VAS scale (Fig. 5).

4. Discussion

Variable magnetic field and infrared radiation have been used in physical medicine for many years. Biological effects achieved using this method result from electrodynamic, magnetodynamic and ion cyclotron resonance effects on cellular metabolism in its broader sense [30], [26]. In dentistry, analgesic effect of variable magnetic fields is usually reported in oral surgery. Dawiec et al. [5] conducted a study on 20 patients with partially or completely impacted third molar teeth in the mandible. The authors assessed the reduction of pain after using Viofor JPS device with A3, M2, P2 field parameters and intensity level of 4. They observed reduction of pain and relaxation effect in areas where the spot applicator had been applied. Jędrzejewski et al. [14] conducted a study on reduction of pain on 30 patients suffering from trigeminal neuralgia and temporomandibular joint arthropathy. They performed a series of 10 procedures over 10 days. Reduction or elimination of pain was observed in all of the analyzed patients after 7 days of therapy. After 2 weeks following the last procedure, recurrence of pain appeared in 2 patients with neuralgia and in 4 weeks – in the other 2 patients. In the group of patients with temporomandibular joint arthropathy, patients reported occasional pain while eating after 4 weeks by using Viofor JPS System [14]. Very similar results concerning patients with neuralgia were also obtained by Bryl et al. [3]. Koszowski et al. [18] compared the analgesic effects of laser stimulation (Doris CTL 1106) and magnetostimulation (Viofor JPS) before dental surgical procedures. The study group was subject to variable magnetic fields (parameters: M2 – amplitude with increasing intensity, P2 – the basic therapeutic program Viofor JPS has three signals: electrodynamic, magnetomechanic and ion cyclotron resonance, intensity: 4, duration: and exposure time was 12 minutes). A laser application included: 50 mW laser power, energy, 4 J/cm^2 and exposure time 1.20 s. It was observed that both patients after laser therapy and magnetostimulation reported much less intense pain and much less intake of non-steroid anti-inflammatory drugs than patients from the control group [18]. Such results confirm the authors' [18] studies despite various parameters used for magnetostimulation. In our study, after talking in the Chair and Clinical Ward of Internal Diseases, Angiology, and Physical Medicine; Centre of Diagnostics and Laser Therapy in Bytom, P1 was used for patients hypersensitive to an alternating magnetic field, having one type of simplified structure and pulses and M3 mode amplitude of the incrementally-decreasing intensity. These parameters give also a positive effect of pain reduction in patients after implantation treatment. On the basis of a study conducted on 63 patients, Jankowska et al. [13] assessed reduction of pain in the facial part of the cranium of various etiologies. After 20 therapeutic cycles using low-frequency variable magnetic fields, the authors achieved satisfactory results [13]. László et al. [21]

studied the analgesic effect in patients with symptoms such as temporomandibular disorders, on alveolitis and on aphta in the oral mucosa. The study was randomized, double-blind, placebo controlled mode. It has been found that the use of magnetic field therapy is an important factor in reducing pain perception in the group with temporomandibular disorders, but not in the case of the alveolitis, or the aphta. Temporomandibular disorders were also studied by Panhoca [24]. He compared the effect of low-level laser therapy with infrared LED therapy in a group of 30 patients. There was a significant reduction of pain in both groups. It was concluded that the LED is an alternative therapy equally with LLLT [24]. Another study was conducted with the participation of 54 patients with sensations of pain during orthodontic treatment. LED therapy was used. Results of these studies showed an improvement in 56% of these orthodontic patients [8]. Beneficial effect of magnetic fields was also earned by Thomas, who used a randomized, double-blind, placebo-controlled group of patients with fibromyalgia chronic localized musculoskeletal or inflammatory pain. The treatment consisted of exposure to the magnetic field twice a day for 40 minutes for 7 days [36]. Interesting properties of magnetic fields were shown by Skromko et al. [31]. The study included 84 patients who used metal fillings amalgam and metal prosthetic restorations. Electric potentials were assessed in the oral cavity of patients after using a magnetic field. The conclusions presented a huge pulsed electromagnetic field on the inhibition of electrochemical processes [31]. In general medicine, analgesic effect of low-frequency variable magnetic field is very extensive, which has been confirmed by a number of publications [32], [25], [19], [39], [2], [4]. Felites et al. [9] compared the effect of the analgesic effect on 40 patients with stomatitis treated with chemotherapy. For this purpose, the analgesic therapy effect of using light-emitting diode and laser phototherapy suggested that LED therapy is more effective than LPT. Other publications devoted to animal testing confirm analgesic effect of magnetostimulation [16], [20], [37]. In our study, through the use of a magnetic field and LED therapy there was obtained a reduction in traumatic experiences of patients and shorter postoperative rehabilitation. In addition, the need for pain medicaments was reduced. In the study group, patients were treated with much weaker analgesics (ibuprofen), or did not take them at all. Just as Koszowski et al. have demonstrated, reduced was the need for non-steroidal anti-inflammatory drugs. Effects of light and variable magnetic fields at the tissue level have similar or complementary nature in clinical medicine. Vital tissue has photoreceptors that absorb light and transmit their excitation to biomolecules important for cellular physiology. Intensification of oxygen absorption process by the influence of variable magnetic fields and the resulting improvement of tissue respiration and cellular metabolism, stimulate activation of the electron transport chain. Free radicals in low concentrations have a stimulating effect on living organisms. Such actions improve regeneration of tissues, facilitate anti-inflammatory and anti-edematous response under the influence of both of the above mentioned forms of electromagnetic radiation. The analgesic effect is obtained mainly through an increase in the secretion of endogenous opiates from the group of beta-endorphins, the substance responsible for the increase in the threshold of pain sensation. The effect of the analgesic action occurs not only during exposure to the magnetic field, but it is also concluded after cessation of exposure. This is a biological hysteresis of magnetic field action. That such a mechanism of analgesic reacts on the internal opioid system confirms the effect of blocking opiate antagonist. It limits the transduction of pain stimuli in afferent fibers, thus increasing the analgesic effect significantly [33], [30], [35], [40]. The studies presented confirm positive analgesic effect of variable magnetic fields with parameters commonly used in magnetostimulation and infrared radiation emitted by LEDs. Pain intensity levels according to VAS scale were reduced significantly in all of the analyzed groups. Reduction of pain intensity was achieved in the group with "Z applicator", which greatly improved patients' well-being. Statistically significant reduction of analgesic intake was also observed. Therefore, magnetostimulation and magnetoledtherapy deserve dentists' attention, especially with regard to supplementary pain management, as it provides a significant relief and improves patients' comfort.

In conclusion, magnetostimulation reduces patient's demand for analgesics after implantation procedures. Magnetostimulation yielded better effects in reduction of pain in comparison with magnetostimulation with LED therapy in the analyzed group of patients. The difference in the effect of magnetic stimulation and LED therapy to reduce pain and the need for pain medications is the patient's subjective experience and requires further research.

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