A selection of relevant scientific articles on microcurrent

Names of authors. Title of the article. Name of magazine. Date of publication. Volume/ Pages. PubMed. DOI number.

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The Quote

1. Roger A, Reynders A, Hoeffel G, Ugolini S. Neuroimmune crosstalk in the skin: a delicate balance governing inflammatory processes. Current Opinion in Immunology. August 2022, Volume 77, 102212. doi:10.1016/j.coi.2022.102212.

"The skin is... innervated by a dense meshwork of primary sensory neurons... Neuroimmune crosstalk in the skin is crucial for the regulation of inflammation, tissue repair, and host defense against pathogens..."

2. Elmasry J, Loo C, Martin D. A systematic review of transcranial electrical stimulation combined with cognitive training. Restorative Neurology and Neuroscience 2015; 33(3): 263-278. doi: 10.3233/RNN-140473.

"Transcranial Electrical Stimulation (tES) methods have been shown to enhance performance across a range of cognitive tasks."

3. Saniee F, Ghafarian Shirazi HR, Khademi K. Consider of Micro-Current's effect to variation of Facial Wrinkle trend, Randomized Clinical Trial Study. Life Science Journal 2012; 9(3):1184-1189.

" Keywords: skin, beauty, Facial, Wrinkle, Micro-Current.
Micro current, recovers facial wrinkles, this recovery was better in the frontal area comparing the nose and mouth. Also comparing the scores of photos, immediately after treatment and one month later shows that not only the effect of treatment has been stable but also the started recovery procedure has been continued after treatment. Treatment satisfaction among patients was over 70%."

4. Piras A, Zini L, Trofè A, Campa F, Raffi M. Effects of Acute Microcurrent Electrical Stimulation on Muscle Function and Subsequent Recovery Strategy. Int J Environ Res Public Health. 2021 May;18(9): 4597. doi: 10.3390/ijerph18094597.

"Microcurrent electrical neuromuscular stimulation (MENS) is believed to alter blood flow, increasing cutaneous blood perfusion, with vasodilation and hyperemia.
MENS applied before exercise produced an increase in oxygen extraction at muscle microvasculature. MENS applied after exercise improved recovery,...."

5. Cho Seungkwan, Kim Seong Guk, Kim Yong-Min, Park Se-Keun, Lee Chi Hwan, Kim Hansung. Clinical Test for Evaluation of Effectiveness of the Micro – current Stimulation in Facial Skin Care. The Korean Society of Medical and Biological Engineering. Journal of Biomedical Engineering Research. Volume 37 Issue 5 Pages 195-207. 2016. doi.org/10.9718/JBER.2016.37.5.195

"... From the clinical test, our results showed that a variety of evaluating categories, which is able to assess the skin qualities, significantly enhanced due to stimulation of micro-current after 7 and 14 days. Therefore, we can estimate that MCS – Micro Current Stimulation – in human facial skin may be effective to improve the skin qualities."

6. de Bellefonds C. Brainy Beauty: Can Electrolytes Really Hydrate Your Skin? Brainy Beauty. August 7, 2020.

"In the skin, electrolytes help conduct electricity when mixed with water, enabling cells to regulate pH levels and keep the body's hydration system in check..... . They can help your skin to retain water... and [could] eventually help your skin get better at holding onto hydration."

7. Morin M, Ruzgas T, Svedenhag P, Anderson CD, Ollmar S, Engblom J, Björklund S. Skin hydration dynamics investigated by electrical impedance techniques in vivo and in vitro. Scientific Reports. 2020 Oct 14;10(1):17218. doi: 10.1038/s41598-020-73684-y.

"... Firstly, hydration between 5 and 10 min results in a drastic skin impedance change, which is interpreted as filling of superficial voids in skin with conducting electrolyte solution. Secondly, a subtle impedance change is observed over time, which is interpreted as leveling of the water gradient across skin leading to structural relaxation/changes of the macromolecular skin barrier components."

8. Donghyun H, Hana L, Jinho L, Minjoo L, Seungkwan C, Tackjoong K, Hansung K. Micro-Current Stimulation Has Potential Effects of Hair Growth-Promotion on Human Hair Follicle-Derived Papilla Cells and Animal Model. Int J Mol Sci. 2021 Apr 22;22(9):4361. PubMed.ncbi.nlm.nih.gov/33921970/. doi: 10.3390/ijms22094361.

"Keywords: alopecia; hair growth; human hair follicle dermal papilla cell; micro-current stimulation (MCS).
This study aimed to investigate the hair growth-promoting effect of MCS on human hair follicle-derived papilla cells (HFDPC) and a telogenic mice model.
Various growth factors in developing hair follicles, including Wnts, FGFs, IGF-1,
and VEGF-B except for VEGF-A, significantly increased in MCS-applied mice. Our results may confirm that MCS has hair growth-promoting effect on HFDPC as well as telogenic mice model, suggesting a potential treatment strategy for alopecia."

9. Garner AL, Torres AS, Klopman S, Neculaes B. Electrical stimulation of whole blood for growth factor release and potential clinical implications. Med Hypotheses. 2020 Oct;143:110105. doi: 10.1016/j.mehy.2020.110105.

"We hypothesize that electric pulses (EPs) can release growth factors from WB (Whole Blood), as they do from PRP, without requiring centrifugation of WB into PRP. A pilot study for two donors demonstrates the potential for EP stimulated growth factor release from WB."

10. Torres AS, Caiafa A, Garner AL, Klopman S, LaPlante N, Morton C, Conway K, Michelson AD, Frelinger 3rd AL, Neculaes B. Platelet activation using electric pulse stimulation: growth factor profile and clinical implications. Journal of Trauma and Acute Care Surgery 2014 Sep; 77(3 Suppl 2); S94-S100. doi: 10.1097/TA.0000000000000322.

"In this study, we identified specific requirements for a clinically relevant activator instrument by dynamically measuring current, voltage, and electric impedance for platelet-rich plasma samples. From these samples, we investigated the profile of growth factors released from human platelets with electric pulse stimulation...
Electric pulse stimulation triggers growth factor release from platelet -granules at the same or higher level compared with BT (Bovine Thrombine)."

11. Mignini F, Sabbatin M, Coppola L, Cavallotti C. Analysis of Nerve Supply Pattern in Human Lymphatic Vessels of Young and Old Men. Lymphatic Research and biology. 2012 Dec; 10(4):189-97. doi:10.1089/lrb.2012.0013.

"The presence on lymph vessels of sympathetic and parasympathetic nerve systems can be declared."

12. Bannerman C. The Sensory Neuron – to – Lymph Node Connection: Understanding an Important Player in Peripheral Neuroimmune Communication. Pain and research forum. March 11, 2021.

"Many studies have shown interactions between the peripheral nervous system and immune system. But a detailed understanding of interactions between neurons and lymph nodes, and why this communication may be important, has remained elusive.
But now, new work led by Ulrich von Andrian, Harvard Medical School, Boston, US, reveals that multiple subsets of sensory neurons innervate lymph nodes."

13. Huang S, Ziegler CGK, Austin J, Mannoun N, Vukovic M, Ordovas-Montanes J, Shalek AK, von Andrian UH. Lymph nodes are innervated by a unique population of sensory neurons with immunomodulatory potential. Cell. 2021 Jan 21;184(2):441-459.e25. doi: 10.1016/j.cell.2020.11.028.

"...we identified and functionally tested a sensory neuro-immune circuit that is responsive to lymph-borne inflammatory signals... Thus, a unique population of sensory neurons monitors peripheral lymph nodes..."

14. Wang PL, Czepielewski RS, Randolph GJ. Sensory Nerves Regulate Transcriptional Dynamics of Lymph Node Cells. Trends Immunol. 2021 Mar;42(3):180-182. PubMed.ncbi.nlm.nih.gov/33563563. doi: 10.1016/j.it.2021.01.008

"The nervous system plays important roles in homeostasis and inflammatory responses in tissues. However, the regulation of lymph nodes (LN) by nerves remains largely unknown. Huang et al. demonstrate that LNs are innervated by unique peptidergic nociceptors that signal to various endothelial, stromal, and immune cell types in LNs."

15. Anderson M, Shelke N B, Manoukian O S, Xiaojun Yu, McCullough L D, Kumbara S G. Peripheral Nerve Regeneration Strategies: Electrically Stimulating Polymer Based Nerve Growth Conduits. Crit Rev Biomed Eng. 2015; 43(2-3): 131–159.
doi: 10.1615/CritRevBiomedEng.2015014015.

"Electrical stimulation (ES) has been applied toward the repair and regeneration of various tissues such as muscle, tendon, nerve, and articular tissue both in laboratory and clinical settings.

In studies where the right tibialis anterior (TA) and extensor digitorum longus (EDL) muscles of Sprague-Dawley rats were stimulated for 8 h/day for seven days, chronic ES induced vessel proliferation (increased vessel density) and increased expression of VEGF protein in the stimulated skeletal muscle.48 Many recent publications report the use of electrically conductive polymer derived conduits to enable ES locally, at the repair site, to promote tissue regeneration."

16. Huang S, Ziegler CGK, Austin J, Mannoun N, Vukovic M, Ordovas-Montanes J, Shalek AK, von Andrian UH. Lymph nodes are innervated by a unique population of sensory neurons with immunomodulatory potential. Cell Volume 184, Issue 2, 21 January 2021, Pages 441-459.e25. doi.org/10.1016/j.cell.2020.11.028.

"We established the lymph nodes as a point of convergence between the sensory nervous system and the immune system by identifying a molecularly distinct and heterogeneous population of sensory neurons with the capacity to affect LN function and homeostasis"

17. Armstrong K, Gokal R, Todorsky T. Treatment of Chronic Post-Surgical Pain Using Microcurrent Point Stimulation Applied to C-Section Scars. Special Issue: Acupuncture for Women's and Children's Health. OBM Integrative and Complementary Medicine 2019, Volume 4, Issue 3. doi:10.21926/obm.icm.1903056.

"Chronic post-surgical pain can limit quality of life, restrict work and social engagement, and is often blamed for the development of drug dependency of various forms. This study showed MPS (Micocurrent Point Stimulation) therapy applied to C-section scars provided statistically significant reduction in initial post-surgical pain levels with a further reduction after a 48-hour follow-up."

18. Curtis D, Fallows S, Morris M, Mc Makin C R. The efficacy of frequency specific microcurrent therapy on delayed onset muscle soreness. Journal of Bodywork and Movement Therapies. Volume 14, Issue 3, July 2010, Pages 272-279. PMID: 20538225. doi: 10.1016/j.jbmt.2010.01.009.

"The results of this study show that at the parameters selected for this investigation FSM (frequency specific microcurrent) therapy did provide significant protection from post-exercise muscle soreness."

19. Mc Makin C R. Microcurrent therapy: a novel treatment method for chronic low back myofascial pain. Journal of Bodywork and Movement Therapies. Volume 8, Issue 2, April 2004, Pages 143-153. doi.org/10.1016/j.jbmt.2003.12.006.

"Microcurrent therapy has traditionally been used to increase the rate of healing in injured athletes, to manage pain, increase the rate of fracture repair, and to treat myofascial pain and dysfunction."

20. Naclerio F, Moreno-Perez D, Seijo M, Karsten B, Larrosa M, Jose Ánge L. García-Merino. Effects of adding post-workout microcurrent in males cross country athletes. European Journal of Sport Science. Volume 21, 2021 - Issue 12. doi.org/10.1080/17461391.2020.1862305.

"The post-workout microcurrent application promoted more desirable changes in body composition and attenuated the perception of delayed onset of muscle soreness over 72-h post-exercise."

21. Mc Makin C R, Gregory W M, Phillips T M. Cytokine changes with microcurrent treatment of fibromyalgia. Journal of Bodywork and Movement Therapies
Volume 9, Issue 3, July 2005, Pages 169-176. doi.org/10.1016/j.jbmt.2004.12.003.

"Symptoms of fibromyalgia following cervical spine trauma were successfully treated with micro amperage current. Subjective pain improvement scores were accompanied by substantial reduction in serum levels of the inflammatory cytokines IL-1, IL-6, and TNF-a; and the neuropeptide substance P. Beta endorphin release and increases in serum cortisol were also observed in these patients during the same treatment period."

22. Dong Rak Kwon, Kang Lip Kim and Yong Suk Moon. Regeneration of Chronic Rotator Cuff Tear in a Rabbit Model: Synergetic Benefits of Human Umbilical Cord Blood-Derived Mesenchymal Stem Cells, Poly deoxyribonucleotides, and Microcurrent Therapy. BioMed Research International. Volume 2022. Article ID 6496773. doi.org/10.1155/2022/6496773.

"It appears that injection of intralesional mesenchymal stem cells derived from human umbilical cord blood (UCB-MSCs) and polydeoxyribonucleotide (PDRN) combined with microcurrent therapy (MIC) might be the most effective regenerative method in rabbit models' traumatic full thickness rotator cuff tendon tear (FTRCTT)."

23. Lawson D, Lee K H, Hyun Bin Kang, Nan Yang, Llewellyn T, Shozo Takamatsu. Efficacy of microcurrent therapy for treatment of acute knee pain: A randomized double-blinded controlled clinical trial. Clin Rehabil. 2021 Mar;35(3):390-398. Epub 2020 Oct 23. doi. org/10.1177/0269215520965320

"Microcurrent therapy significantly reduced pain over 4 weeks. The analysis on SF-12 revealed those with microcurrent therapy showed an increasing trend in the improvement of physical function score until week three."

24. Iijima H, Takahashi M. Microcurrent Therapy as a Therapeutic Modality for Musculoskeletal Pain: A Systematic Review Accelerating the Translation From Clinical Trials to Patient Care. Arch Rehabil Res Clin Transl. 2021 Jul 21;3(3):100145. doi:10.1016/j.arrct.2021.100145.

"A comprehensive assessment of 4 RCTs and 5 non-RCTs that met the inclusion criteria revealed that MCT(MicroCurrentTherapy) significantly improved shoulder pain (1 study, 40 patients) and knee pain (1 study, 52 patients) compared with sham MCT without any severe adverse events. MCT (MicroCurrentTherapy) has clinically significant benefits for knee pain."

25. Lambert M I, Marcus P, Burgess T, Noakes T D. Electro-membrane microcurrent therapy reduces signs and symptoms of muscle damage. Med. Sci. Sports Exerc., Vol. 34, No. 4, pp. 602–607, 2002.

"The subjects experienced severe pain and swelling of the elbow flexors. The treatment of muscle damage with microcurrent therapy reduces the severity of the postoperative pain and soft tissue injury."

26. Tae-Rin Kwon, Dong Wook Moon, Jungwook Kim, Hyoung Jun Kim, Seong Jae Lee, Yunhee Han, Hee Won Dan, Sang Hoon Chi, Hwan Mo Seong, Hee Jung Kim, Guei-Sam Lim, Jungkwan Lee. Application of 630-nm and 850-nm Light-emitting Diodes and Microcurrent to Accelerate Collagen and Elastin Deposition in Porcine Skin. Med Laser 2021; 10(2): 96-105. doi.org/10.25289/ML.2021.10.2.96.

"Histological staining revealed that accurate treatment of the targeted dermis layer effectively enhanced collagen and elastin deposition. Collagen type I, a protein defined by immunohistochemical staining, was overexpressed in the early stages of weeks 2 and 6. Combined therapy findings showed the superior capability of the 630-nm and 850-nm LED procedures to induce collagen; in contrast, elastin induction was more pronounced after microcurrent treatments."

27. Poltawski L, Johnson M, Watson T. Microcurrent Therapy in the Management of Chronic Tennis Elbow: Pilot Studies to Optimize Parameters. Physiotherapy Research International. 2012 Sep; 17 (3):157-66. doi.org/10.1002/pri.526.

"Monophasic MCT (microcurrent therapy) of peak current intensity 50 µA applied for tens of hours is effective in reducing symptoms and promoting tendon normalization in chronic tennis elbow."

28. Goldsobel A B, Prabhakar N, Gurfein B T. Prospective trial examining safety and efficacy of microcurrent stimulation for the treatment of sinus pain and congestion. Bioelectron Med 5, 18 (2019). doi.org/10.1186/s42234-019-0035-x.

"This study demonstrated that non-invasive bioelectronic microcurrent therapy acutely reduced rhinologic facial pain for up to 6 h and, with regular use, alleviated the severity of sinus pain and nasal congestion over 4 weeks."

29. Iijima H, Takahashi M. Microcurrent Therapy as a Therapeutic Modality for Musculoskeletal Pain: A Systematic Review Accelerating the Translation From Clinical Trials to Patient Care. Archives of Rehabilitation Research and Clinical Translation. 2021 Jul 21;3(3):100145. doi.org/10.1016/j.arrct.2021.100145.

"Microcurrent therapy is a potential, core nonpharmacologic treatment option in clinical care with minimal adverse events. Microcurrent therapy is a new Food and Drug Administration–approved electrotherapy for treating musculoskeletal pain."

30. Gabriel A, Sobota R, Gialich S, Maxwell P. The Use of Targeted Micro Current Therapy in Postoperative Pain Management. Plastic Surgical Nursing. 2013 Jan-Mar;33(1):6-8. doi: 10.1097/PSN.0b013e3182844219.

"Micro Current Therapy enhances postsurgical recovery by stimulating the body's natural healing process. This therapy transmits gentle, short bursts of electrical current targeted to the tissue cells at the surgical site."

31. Koopman J, Vrinten DH, van Wijck AJM. Efficacy of Microcurrent Therapy in the Treatment of Chronic Nonspecific Back Pain: a pilot study. Clin J Pain. 2009 Jul-Aug;25(6):495-9. doi: 10.1097/AJP.0b013e31819a6f3e

"Mean and worst pain scores were evaluated daily by a visual analog scale (VAS). The VAS score was lower during micro current therapy (MTC) treatment, with a reduction [95% confidence interval (CI] of -0.43 (-1.74; 0.89) in mean and -1.07 (-2.85; 0.71) in worst pain. Analgesic use decreased and the quality of life improved during MTC treatment."

32. Zizic T M, Hoffman K C, Holt P A, Hungerford D S. Treatment of osteoarthritis of the knee with pulsed electrical stimulation. The Journal of Rheumatology. 1995 Sep;22(9):1757-61.

"Recent advances in technology have led to the development of a noninvasive device, targeted Micro Current Therapy, which enhances postsurgical recovery by stimulating the body's natural healing process."

33. Garland D E, Holt P, Harrington T, Cholewczynski J. A 3-month, randomized, double-blind, placebo-controlled study to evaluate the safety and efficacy of a highly optimized, capacitively coupled, pulsed electrical stimulator in patients with osteoarthritis of the knee. Osteoarthritis and Cartilage 2007 Jun;15(6):630-7. doi:10.1016/j.joca.2007.01.004.

"Active electro-stimulation treatment of these patients with moderate to severe knee osteoarthritis provided significant and clinically meaningful improvement relative to placebo in four of five primary outcome measures ….. "

34. Bailey S. How Microcurrent Stimulation Produces ATP -- One Mechanism. Dynamic Chiropractic. August 23,1999, Vol.17, Issue 18.

"ATP (adenosine triphosphate) molecules are the storage and distribution vehicles for energy in the body. Clinically, microcurrent stimulation is not at all limited to its effects of increased ATP production in its capacity as a treatment modality, but its effects to reduce injury healing time in half are truly dramatic."

Definition of ATP.
Adenosine 5'-triphosphate, or ATP, is the principal molecule for storing and transferring energy in cells. It is often referred to as the energy currency of the cell and can be compared to storing money in a bank.

35. Cheng N, Van Hoof H, Bockx E, Hoogmartens MJ, Mulier JC, De Dijcker FJ, Sansen WM, De Loecker W. The effects of electric currents on ATP generation, protein synthesis, and membrane transport of rat skin. Clin Orthop Relat Res 1982 Nov-Dec;(171):264-72. Pubmed.ncbi.nlm.nih.gov/7140077/.

"Direct electric currents ranging from 10 microA to 1000 microA increase ATP concentrations in the tissue and stimulate amino acid incorporation into the proteins of rat skin."

36. Carley PJ, Wainapel SF. Electrotherapy for acceleration of wound healing: low intensity direct current. Arch Phys Med Rehabil. 1985 Jul;66(7):443-6. PubMed.ncbi.nlm.nih.gov/3893385/.

"Accelerated wound healing (1.5 to 2.5 times faster) has been an observed effect of low intensity direct current (LIDC). The wounds treated with LIDC required less debridement and the healed scars were more resilient. Additionally, no wound infections occurred and patients reported less discomfort at the wound site."

37. Xinkai Xu, Han Zhang, Yan Yan, Jianru Wang, Liang Guo. Effects of electrical stimulation on skin surface. Acta Mechanica Sinica. 2021;37(12), pages 1843–1871. doi.org/10.1007/s10409-020-01026-2.

"Micro-current stimulation, as a relatively safe and non-invasive noninvasive therapy, has been applied to many fields of medicine since its discovery, and has been greatly developed, allowing researchers to see new possibilities. Transdermal drug delivery, wound healing, analgesia and postoperative muscle rehabilitation has gradually expanded to non-medical fields in recent years. In current drug delivery therapy, the principle and efficacy of iontophoresis had been widely recognized, and the effect is very good"

38. Cázares-Delgadillo J, Planard-Luong L, Gregoire S, Serna-Jiménez C E, Singhal M, Kalia Y N, Merino V, Merino-Sanjuán M, Nácher A, Martínez-Gómez A, Burnier-Yalaoui V, Barbarat P. Investigation of different iontophoretic currents profiles for short-term applications in cosmetics. Pharmaceutics. 2018 Dec 7;10(4):266. doi: 10.3390/pharmaceutics10040266.

"A few studies have reported on the delivery of ascorbic acid (AA) using galvanic direct current (DC) profiles to achieve a clinical improvement in melasma. An increase in skin collagen synthesis induced by an AA derivative after "frequent-reversal bipolar electrical iontophoresis" has also been reported.
It suggests also that a DC current led to the best delivery of AA (for the concentrations of 5% and 10% AA), as it increases the skin permeability and enhanced passive diffusion of neutral AA"

39. Lathrop PH. Physiological effects of microcurrent on the body. Apr. 26, 2011.

- Reduction in pain improvement scores with accompanying substantial reduction in serum levels of the inflammatory cytokines IL-1, IL-6, and TNF-X, and neuropeptide substance P. Beta- endorphin release and increases in serum cortisol.
- Significant pain reduction and increased range of motion in chronic backpain, fibromyalgia, cervical pain, Carpal Tunnel Syndrome, and arthritis patients
- Reduction of pain in degenerative joint disease of the temporomandibular joint
- Lasting reduction in myofascial pain of the head, neck and face
- Reduction in pain and increased mobility in peritendinitis area of the shoulder
- Reduction in post-operative pain and edema,
- Reduction in healing time in soft tissue injury
- Reduce in treatment and rehabilitation time and reduction in worker down time
- Increasing range of motion in ankle dorsiflexion in CP,
- Increase the rate of healing in injured athletes, pain, increase the rate of fracture repair, and treat myofascial pain and dysfunction
- Reduction in pain at power-grip and lifting a weight load with pronated forearm, improvement in grip-strength in chronic lateral epicondylitis patients,
- Superiority to conventional physical therapy in number of treatments required to relieve pain, severity of side effects, total cost of treatment and patient satisfaction,
- Reduce severity of muscle damage signs and symptoms.

40. Santos VNS, Ferreira LM, Horibe EK, Duarte IS. Electric microcurrent in the restoration of the skin undergone a trichloroacetic acid peeling in rats. Acta Cir. Bras. Oct 2004; 19(5). doi:10.1590/S0102-86502004000500003

"MENS (Microcurrent Electric Neuromuscular Stimulation) reduced the period of restoration of the area submitted to peeling with TCA peelings in the skin of rats."

41. Fujita M, Hukuda S, Doida Y. The effect of constant direct electrical current on intrinsic healing in the flexor tendon in vitro. An ultrastructural study of differing attitudes in epitenon cells and tenocytes. Hand Surg Br. 1992 Feb;17(1):94-8. Pubmed.ncbi.nlm.nih.gov/1640154/. doi: 10.1016/0266-7681(92)90021-s.

"Electrical currents of low amperage suppresses adhesion-causing synovial proliferation in the epitenon and promotes active collagen synthesis in the tenocytes. This suggests the potential value of electrical stimulation in the control of adhesion formation after flexor tendon repair."

42. Bourguignon G J, Jy W, Bourguignon L Y. Electric stimulation of human fibroblasts causes an increase in Ca2+ influx and the exposure of additional insulin receptors. J Cell Physiol. 1989Aug;140(2):379-85. Pubmed.ncbi.nlm.nih.gov/2663886/. doi: 10.1002/jcp.1041400224.

"Previously we reported that treating human fibroblasts in cell culture with high-voltage, pulsed galvanic stimulation (HVPGS) can significantly increase cellular protein and DNA synthesis (Bourguignon and Bourguignon: FASEB J., 1:398-402, 1987). In this study we have identified two of the early cellular events which occur following exposure to HVPGS: 1) an increase in Ca2+(Calcium ion) uptake from the external medium and 2) an increase in the number of insulin receptors on the fibroblast cell surface. The increase in Ca2+ uptake begins within the first minute of electric stimulation while increased insulin binding is not detected until the second minute of stimulation."

43. Korenstein R, Somjen D, Fischler H, Binderman I. Capacitative pulsed electric stimulation of bone cells. Induction of cyclic-AMP changes and DNA synthesis. Biochim Biophys Acta. 1984 Apr 16;803(4):302-7. PubMed.ncbi.nlm.nih.gov/6322860/. doi: 10.1016/0167-4889(84)90121-6.

"Pulsed electric stimulation, coupled capacitively to bone cells isolated from rat embryo calvaria, caused changes in the intracellular level of cyclic AMP (Adenosine monophosphate) and enhanced DNA synthesis"

44. Griffin M, Resa M, Bayat A. Electrical Stimulation in Bone Healing: Critical Analysis by Evaluating Levels of Evidence. Eplasty. 2011; 11: e34. PMC3145421 Published online 2011 Jul 26.

"As result of this study, direct current was found to be effective in enhancing bone healing in spinal fusion. Eleven studies made on the subject demonstrate that ES (Electrical Stimulation) enhances bone healing by changes in growth factors and transmembrane signaling although no clear mechanism has been defined."

45. Lowy D B, Makker P G S, Moalem-Taylor G. Cutaneous Neuroimmune Interactions in Peripheral Neuropathic Pain States. Front Immunol. 2021 Apr 12;12:660203. doi: 10.3389/fimmu.2021.660203.

"The skin is a diverse organ protecting the host from the external environment. The skin is home to an array of sensory nerve endings and specialized immune cells, both with heterogeneous functionality. Neuroimmune interplay between sensory nervous system and the immune system in the skin is crucial in homeostasis and disease states"

46. Scientific and Clinical Studies on Microcurrent. Twelve (12) studies. Joseph V (1983), Zizic TM (1995), Brighton CT, Wallace LA (1990), Nessler and Mass (April 1987), Stanish and Gunlaughson (1988), Richez, Chamay and Bieler (1972), Heffernan M (1996).

1. Cell regeneration and ATP production
2. Osteoarthritis of the knee
3. Glycosaminoglycan production
4. Pain reduction
5. Sport injuries
6. Bone reunion
7. Headaches and migraines
8. Temporomandibular Joint (TMJ) Disorders
9. Low back pain
10. Blood circulation
11. Edema and swelling reduction
12. Wound healing

47. Jin Kuk Do, Dong Rak Kwon. Efficacy of cranial microcurrent stimulation in patients with tension-type headache: A prospective, randomised, double-blinded, sham-controlled clinical trial. International Journal of Clinical Practice. September 2021;Volume75, Issue9, e14437. doi.org/10.1111/ijcp.14437

"The results indicate that CMS (cranial microcurrent stimulation), as an adjunctive treatment for patients with TTH (tension-type-headache), is safe and analgesic as well as reducing depression or anxiety."