

# Effect of diamagnetic therapy to manage a patient with degenerative cervical myelopathy and drug's intolerance

Vincenzo Rania, Gianmarco Marcianò, Cristina Vocca, Caterina Palleria, Lucia Muraca, Pietro Romeo, Felipe Torres & Luca Gallelli

To cite this article: Vincenzo Rania, Gianmarco Marcianò, Cristina Vocca, Caterina Palleria, Lucia Muraca, Pietro Romeo, Felipe Torres & Luca Gallelli (22 Jun 2025): Effect of diamagnetic therapy to manage a patient with degenerative cervical myelopathy and drug's intolerance, Pain Management, DOI: [10.1080/17581869.2025.2523729](https://doi.org/10.1080/17581869.2025.2523729)

To link to this article: <https://doi.org/10.1080/17581869.2025.2523729>



Published online: 22 Jun 2025.



Submit your article to this journal [↗](#)



View related articles [↗](#)




View Crossmark data [↗](#)

CASE REPORT



## Effect of diamagnetic therapy to manage a patient with degenerative cervical myelopathy and drug's intolerance

Vincenzo Rania<sup>a</sup>, Gianmarco Marciandò <sup>a</sup>, Cristina Vocca<sup>a</sup>, Caterina Palleria<sup>a</sup>, Lucia Muraca<sup>b</sup>, Pietro Romeo<sup>b</sup>, Felipe Torres<sup>a,b</sup> and Luca Gallelli<sup>a,b</sup>

<sup>a</sup>Operative Unit of Pharmacology and Pharmacovigilance, "Renato Dulbecco" University Hospital, Catanzaro, Italy; <sup>b</sup>Research Center FAS@UMG, Department of Health Science, University Magna Graecia, Catanzaro, Italy

### ABSTRACT

Degenerative cervical myelopathy (DCM) is a common condition with a prevalence of 24.2% in the healthy population, and 35.3% in patients older than 60 years. The management of this clinical condition is difficult and implies chronic management of patients. The risk of drug abuse is very high and may lead to important long-term consequences. Finding a therapeutic option capable to reduce the number of prescribed drugs and with few side effects is very important in DCM. We report a 44-year-old Caucasian woman who was diagnosed with DCM. Her medical history revealed that despite using multiple medications, she did not show any signs of improvement. She declined the surgical treatment as well. Following clinical assessment, a diamagnetic pump treatment with pulsed electromagnetic fields for 3 months (once-twice weekly for 30 min, magnetic flux density 86 mT at the site of treatment) resulted in a clinical improvement. The benefits of diamagnetic therapy were three-faced including pain improvement, functional status, and imaging (magnetic resonance imaging (MRI) showing bone marrow edema reduction and myelopathy improvement). This is the first case report in our knowledge to prove the effectiveness of diamagnetic therapy in DCM, alongside imaging and functional improvement.

### CERVICAL PAIN MAY BE CURED ALSO WITHOUT DRUGS – PLAIN LANGUAGE SUMMARY

Cervical pain is very common worldwide. People usually take a lot of drugs for their pain, generating the risk of damages to the body. Diamagnetic therapy, an alternative treatment with no drugs involved, may help patients and citizens to reduce the number of drugs consumed and to improve the signs of their illness. We describe in this article the case of a 44-year-old woman, who did not want drugs or had some issues in consuming them and was managed through the use of a local therapy based on magnetic fields (given with a kind of a plaster), that have no side effects and few reasons for whom you must not do it (for example, if you have a pacemaker or a cancer). The woman improved in their capacity to walk and do physical activity, pain was reduced, and the diagnostic images were better than before therapy.

So, if you have cervical pain, your doctor may consider also this therapy. It needs some days to be completed and the number of days of therapy must be limited, but it is safe.

### ARTICLE HISTORY

Received 7 February 2025

Accepted 19 June 2025

### KEYWORDS

Magnetic fields; cervical pain; intolerance; woman; therapy; case report

## 1. Introduction

Degenerative cervical myelopathy (DCM) is a common condition among the world population, with a prevalence of 24.2% in the healthy population and 35.3% among individuals older than 60 years of age. Arthritic vertebral degeneration favors spinal cord compression in the cervical tract of the spine. Neck pain, burning, electric shock, paresthesia, gait abnormalities, and decreased strength results of the upper limbs, due to the spine compression, are signs and symptoms of the skeletal, muscular, vascular, and nervous structures progressive impairment [1]. This clinical condition is particularly challenging considering the concomitant presence of structural anatomical alterations of the vertebral column (e.g., spondylarthrosis, osteophytes, bulging, and protrusions) and the involvement of the structures of peripheral and/or central nervous systems. The presence of these alterations renders pain refractory, needing

periodic cycles of therapy (see *Discussion*). In patients with DCM not responsive to pharmacological and non-pharmacological treatment, the quality of life could be fair and surgery could be proposed [2–4]. Among non-pharmacological treatments, the pulsed electromagnetic fields (PEMFs), also named diamagnetic therapy, could be used [5].

PEMFs are a noninvasive safety treatment for many musculoskeletal diseases alone or add-on to other therapies [6,7]. PEMFs, produced through pulsing current, are nonionizing, nonthermal, low-frequency dynamic fields with specific waveforms and amplitudes [8]. Their efficacy (especially at frequencies <100 Hz) in inflammatory and motor disorders, as well as in relieving pain has been reported [9]: since the exact mechanism of action on cells hasn't been demonstrated. However, some authors suggested that high-intensity, low-frequency PEMFs affects the ion balance and membrane exchanges propagating

**Article highlights**

- Degenerative cervical myelopathy (DCM) is a common condition among the world population, with a prevalence of 24.2% in the healthy population and 35.3% among individuals older than 60 years of age.
- This condition affects quality of life, requires multiple pharmacological treatments and is often not responsive.
- Pulsed electromagnetic fields (PEMFs) are a noninvasive and safe treatment for many musculoskeletal diseases alone or add-on to other therapies
- We managed a 44-year-old Caucasian woman (weight 65 kg, height 170 cm, Body Mass Index (BMI) 22.49) for a 1-year history of severe neck pain and impairment in daily living. She received several pharmacological therapies with the development of side effects and without clinical efficacy. Numerical Rating Scale (NRS): 10/10.
- After 3 months, twice a week, PEMFs treatment the symptom resolved and also functioning improvement in the 36-Item Short Form Survey (SF-36) questionnaire were observed ( $p < 0.01$ ).

their effects through the signal transduction pathways [10]; this mechanism could play a role on cellular differentiation, proliferation, and activity [11]. It is important to note that PEMFs exert a triple mechanism to manage pain: anti-inflammatory action reducing the production of inflammatory cytokines; anti-oedemic activity through the increase of vascular endothelial growth factor (VEGF), movement of liquids related to nutrients and magnetic substance movement associated to the physical effect of diamagnetism; neuromodulator and neuroprotective effect acting on several targets, including ion channels and Brain-Derived Neurotrophic Factor (BDNF) [7,12–15]. Herein, we present a 44-year-old Caucasian woman with a chronic history of DCM, successfully treated with diamagnetic therapy pump (CTU MEGA 20®-Periso SA. Pazzallo-Switzerland), alongside functional improvement and good recovery of imaging pathologic findings. Diamagnetic therapy through diamagnetic pump (Figure 1) is the best choice for managing patients. In fact, PEMFs are delivered using a handpiece that has a plate on its extremity. In this way, massage therapy may be practiced concomitantly to PEMFs delivery, moving the device slowly. This allows noninvasive treatment, but also a strong proximity to the interested structures.

## 2. Case presentation

A 44-year-old Caucasian woman (weight 65 kg, height 170 cm, Body Mass Index (BMI) 22.49) came to our attention due to a 1-year history of severe neck pain with weakness and burning of the upper limbs, and with a progressive impairment in daily living.

The patient had a history of gastritis, herpes zoster infection, and chronic venous insufficiency. No trauma was referred. She was treated with steroidal and non-steroidal anti-inflammatory drugs (dexamethasone, prednisolone, diclofenac, ibuprofen) without clinical benefit. Moreover, the development of gastrointestinal adverse events (gastric pain and reflux) led to the discontinuation of the treatment. A new treatment with codeine and tramadol was started with the development of stypsis and hypertension. A neurological evaluation diagnosed a DCM, and a treatment with pregabalin



Figure 1. Diamagnetic PUMP.

was started, with an initial clinical benefit, but due to the development of dizziness, pregabalin was changed to amitriptyline plus neurotrophic supplements without clinical benefit. A neurosurgery evaluation confirmed the DCM and suggested the surgery decompression that was refused; therefore, a physiotherapy treatment with capacitive resistive electric transference and laser was suggested, but it did not improve pain or motor function.

In December 2024, the patient came into the pain medicine room of Dulbecco University Hospital, in Catanzaro, Italy, for a new evaluation. At examination, we documented hyperalgesia and allodynia with dermatomal distribution (C4–C5–C6), a brachial plexus positive Valleix sign, hand numbness, and bilateral paresthesia. The severity of her pain was 10/10 on a numeric rating scale (NRS) [16], with an impossibility to tolerate any mechanical stimulation; the Douleur Neuropathique en 4 Questions (DN4) [17] score was 7/10. She also reported impaired

**Table 1.** Short Form Health Survey (SF) 36 recorded in the enrolled patient 3 months (T1) after the admission (T0). Data are expressed as mean  $\pm$  standard deviation of three evaluations for each time. \*\* $p < 0.01$ .

	SF-36		
	T0	T1	P
Physical functioning	25.1 $\pm$ 1.2	61.3 $\pm$ 2.1**	0.000
Role limitations due to physical health	26.2 $\pm$ 2.1	62.7 $\pm$ 1.9**	0.000
Role limitations due to emotional problems	27.3 $\pm$ 1.7	63.1 $\pm$ 1.6**	0.000
Energy/fatigue	29.6 $\pm$ 1.6	67.2 $\pm$ 1.7**	0.000
Emotional well-being	28.3 $\pm$ 1.8	65.1 $\pm$ 1.2**	0.000
Social functioning	31.5 $\pm$ 1.7	70.2 $\pm$ 1.4**	0.000
Pain	23.1 $\pm$ 1.1	62.5 $\pm$ 1.6**	0.000
General health	21.9 $\pm$ 2.8	69.8 $\pm$ 2.1**	0.000
Health change	30.2 $\pm$ 1.0	76.7 $\pm$ 1.1**	0.000

sleep, mainly difficulties in falling asleep. The use of the 36-Item Short Form Health Survey (SF-36) questionnaire revealed a low quality of life [18] (Table 1).

Magnetic resonance imaging (MRI) and electromyography (EMG) were prescribed. The MRI revealed the presence of bone edema at C3-C4 with multiple compressions (Figure 2), and a chronic degenerative myelopathy at C5 (Figure 3); the EMG revealed a slight impairment of the median nerve fibers in the distal tract on the right and left for the sensory and motor component, with concurrent signs of neurogenic suffering in the brachial plexus muscles in the root of the C5 and C6 nerve on the right and left as well as in T1 on the left (modest degree).

A diagnosis of chronic degenerative myelopathy in a patient with mixed pain and drug intolerance was performed. A treatment with both l-acetyl carnitine and pregabalin was suggested but the patient refused it; therefore, a 3-month treatment (biweekly) with diamagnetic therapy was prescribed. During each session of treatment, lasting 30 min, the patient was placed in a prone position and the diamagnetic pump was positioned along the C2-C6 and a new protocol for edema/pain was applied (Table 2).

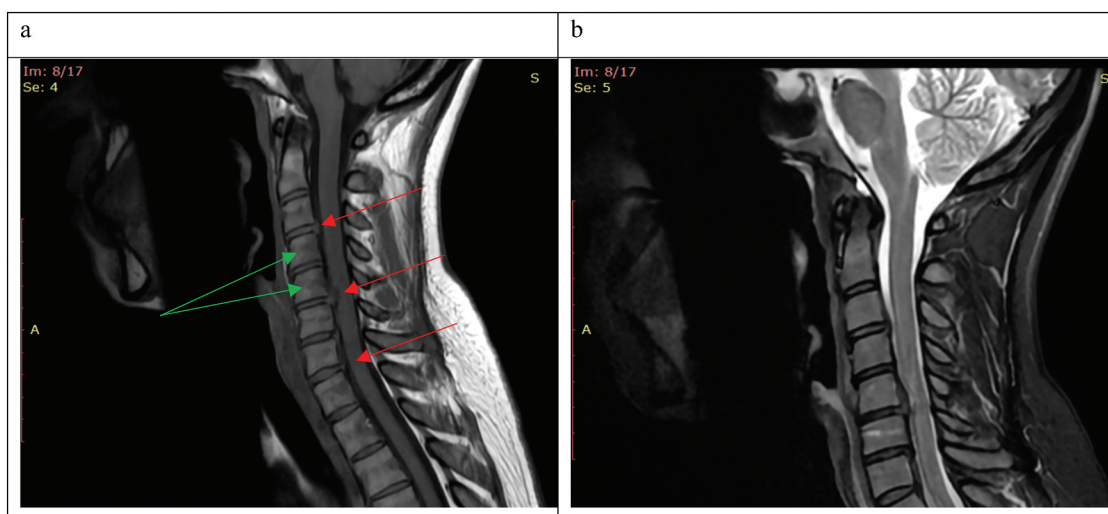
Both NRS and DN4 were evaluated before and after each session of treatment. At the time of admission (T0) and at the end of the treatment (T1: 3-month), the SF-36 questionnaire

was given. NRS and SF-36 were used as indicators of efficacy, while the occurrence of adverse events as indicators of safety.

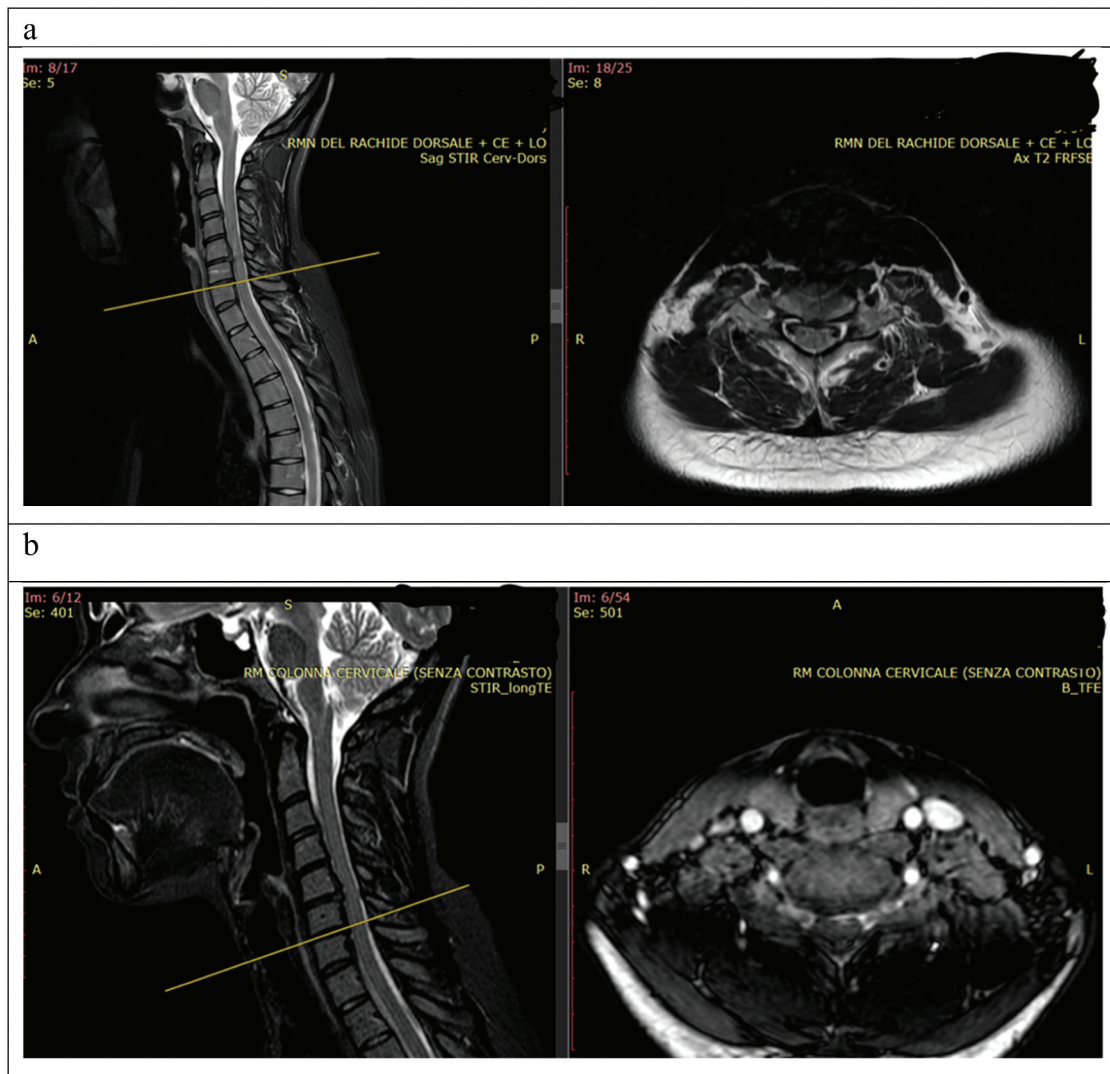
We observed a significant ( $p < 0.01$ ) decrease in pain (NRS: 2/10) and neuropathic symptoms (DN4: 3/10) at the conclusion of the treatment session (T1; week 12), along with improvements in sleep and quality of life (Table 1). Higher scores on the SF-36 questionnaire were noted for physical functioning, role restrictions brought on by emotional and physical health issues, and bodily pain as compared to baseline. Furthermore, MRI imaging improved at the end of the treatment (Figure 3), with reduction of Bone Marrow Edema and myelopathy. Over the course of the treatment, no adverse events were described by patients.

### 3. Discussion

We reported a woman with clinical symptoms related to DCM that improved after 3 months of diamagnetic therapy [19]. Previous data suggested that untreated mild myelopathy could lead to severe impairment of neurological status and severe pain [3]. In this case, our patient denied a history of injury, and probably, the development of this clinical condition is degenerative. Despite the availability of different therapeutic approaches, a large number of patients have a poor outcome, experiencing some lasting



**Figure 2.** T1 fast recovery (FR) fast spin echo (FSE) (a) T1 short TI inversion recovery (STIR) (b) magnetic resonance imaging showing the presence of multiple compressions (C2-C3, C4-C5, C6-C7) (red arrows) with the presence of bone edema in C3 and C4 (green arrows).



**Figure 3.** T1 (short T1 inversion recovery) STIR magnetic resonance imaging in enrolled patient before (a) and after (b) diamagnetic therapy. It is possible to evaluate the decrease in degenerative cervical myelopathy (DCM) in C5-C6.

**Table 2.** Diamagnetic therapy program used in the treated patient.

Program	Time
Liquids movement	8 minutes Intracellular High/Extracellular High
Endogenous Biostimulation	Nerve slow 6 minutes- Cartilage-Bone 6 minutes
Neuropathic pain	High intensity 10 minutes
Magnetic flux density was 86 mT at the site of treatment	

symptoms, chronic pain, and disability, which negatively affect the quality of life [20]. Our patient presented with severe mixed pain, inducing an impairment of the quality of life and of the sleep. Prior treatments failed due to the emergency of adverse drug reactions, while surgery decompression suggested by a specialist in neurosurgery, in agreement with the guidelines [19,21] was refused. In this patient, a non-pharmacological treatment was mandatory, and the inefficacy of previous protocols of physiotherapy suggested a different approach. In fact, diamagnetic treatment improved symptoms and quality. PEMFs move water, ion molecules and biological tissue through the water repulsive effect of diamagnetism [22]; for this reason, the biophysical stimulation carried out with high-intensity,

low-frequency PEMFs is also referred to as diamagnetic therapy.

This may have determined edema reduction also according to diamagnetic therapy anti-inflammatory activity through its action on adenosine receptors  $A_2$  and  $A_3$  (upregulation), nuclear factor kappa-light-chain-enhancer of activated B cells (NF- $\kappa$ B) inhibition [14,23–25]. Furthermore, the pro-angiogenic action improves microcirculation, reducing edema [12,13,26]. Finally, part of the clinical benefit is related to neuroprotective action and modulation of sodium, potassium, and calcium ion channels [15,27–29].

Despite the absence of a high number of studies, pulsed magnetic fields have been used to manage cervical pain as shown by Hattapoglu and colleagues [30]. They observed the

improvement of enrolled subjects concerning pain, sleep, mood, and quality of life on 64 patients with cervical disc herniation, but without reporting data about MRI.

The strengths of this case report are related to the use of a new non-pharmacological approach and to the clinical response not only from the patient's perspective, but also on imaging and on functioning. However, limitations are related to the analysis of a single patient's response and the absence of local inflammation markers measurement.

The limitations of PEMFs are several, but they are easily overcoming through patient's selection. This kind of therapy is contraindicated in patients with active cancer, pacemakers, patients with implanted metallic devices that are not compatible with MRI. It is important to note that, similarly to other pain treatments, diamagnetic therapy is not effective in all patients, particularly in case of very severe structural damage or underlying and not adequately managed inflammatory conditions (e.g., rheumatoid arthritis). The effect on bone marrow edema is generally long-lasting, especially in blunt trauma. However, in patients with myelopathy, cervical pain, low back pain relapse is highly probable and a new cycle after some months, alongside pharmacologic therapy, may be required. Finally, we must observe (despite the presence of other clinical and experimental studies in this and other clinical settings) that results from a single case study are not necessarily indicative of wide-spread applicability.

#### 4. Conclusion

According to this and previous experiences, diamagnetic therapy is a safe option in the management of DCM. Our patient improved in a multi-faced manner including not only pain as a symptom, but also physical functioning and MRI. Further randomized controlled trials with larger sample sizes are necessary to confirm the generalizability of this treatment approach. This case report may be the first to investigate this topic in a broad patient population because of its limitations on the number of enrolled patients.

#### Author contributions

**Vincenzo Rania and Gianmarco Marcianò:** Conceptualization, Methodology, Software **Luca Gallelli:** Data curation, Writing – Original draft preparation. **Cristina Vocca:** Visualization, Investigation. **Caterina Palleria:** Supervision. **Lucia Muraca and Luca Gallelli:** Software, Validation. **Pietro Romeo, Luca Gallelli and Felipe Torres:** Writing-Reviewing and Editing.

#### Disclosure statement

The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties. No writing assistance was utilized in the production of this manuscript.

#### Funding

This paper was not funded.

#### Ethical declaration

The patient provided written informed consent with respect to the type of treatment (during the first admission) and for the publication of this case report.

#### ORCID

Gianmarco Marcianò  <http://orcid.org/0000-0003-1478-9551>

#### References

**Papers of special note have been highlighted as either of interest (\*) or of considerable interest (\*\*) to readers.**

- Nouri A, Tessitore E, Molliqaj G, et al. Degenerative cervical myelopathy: development and natural history [AO spine RECODE-DCM research priority number 2]. *Glob Spine J.* 2022;12(1\_suppl):395–545. doi: [10.1177/21925682211036071](https://doi.org/10.1177/21925682211036071)
- Williams J, D'Amore P, Redlich N, et al. Degenerative cervical myelopathy: evaluation and management. *Orthop Clin North Am.* 2022;53(4):509–521. doi: [10.1016/j.ocl.2022.05.007](https://doi.org/10.1016/j.ocl.2022.05.007)
- Useful insights about degenerative cervical myelopathy.**
- Choi SH, Kang CN. Degenerative cervical myelopathy: pathophysiology and current treatment strategies. *Asian Spine J.* 2020;14(5):710–720. doi: [10.31616/asj.2020.0490](https://doi.org/10.31616/asj.2020.0490)
- Saunders LM, Sandhu HS, McBride L, et al. Degenerative cervical myelopathy: an overview. *Cureus.* 2023;15(lv):1–12. doi: [10.7759/cureus.50387](https://doi.org/10.7759/cureus.50387)
- Roberti R, Marcianò G, Casarella A, et al. Diamagnetic therapy in a patient with complex regional pain syndrome type I and Multiple drug intolerance: a case report. *Reports.* 2022;5(2):18. doi: [10.3390/reports5020018](https://doi.org/10.3390/reports5020018)
- Real-life data about the efficacy of diamagnetic therapy and its mechanism of action.**
- Hu H, Yang W, Zeng Q, et al. Promising application of pulsed electromagnetic fields (PEMFs) in musculoskeletal disorders. *Biomed Pharmacother.* 2020;131:110767. doi: [10.1016/j.biopha.2020.110767](https://doi.org/10.1016/j.biopha.2020.110767)
- Pullano SA, Marcianò G, Bianco MG, et al. FT-IR analysis of structural changes in Ketoprofen lysine Salt and KiOil caused by a pulsed magnetic field. *Bioengineering.* 2022;9(10):503. doi: [10.3390/bioengineering9100503](https://doi.org/10.3390/bioengineering9100503)
- Real-life data about the efficacy of diamagnetic therapy and its mechanism of action.**
- Pasek J, Szajkowski S, Travagli V, et al. Topical hyperbaric oxygen therapy versus local ozone therapy in healing of venous leg ulcers. *Int J Environ Res Public Health.* 2023;20(3):1967. doi: [10.3390/ijerph20031967](https://doi.org/10.3390/ijerph20031967)
- Paolucci T, Pezzi L, Centra AM, et al. electromagnetic field therapy: a rehabilitative perspective in the management of musculoskeletal pain – a systematic review. *J Pain Res.* 2020;13:1385–1400. doi: [10.2147/JPR.S231778](https://doi.org/10.2147/JPR.S231778)
- Real-life data about the efficacy of diamagnetic therapy and its mechanism of action.**
- Delle Monache S, Angelucci A, Sanità P, et al. Inhibition of angiogenesis mediated by extremely low-frequency magnetic fields (ELF-MFs). *PLoS One.* 2013;8(11):1–11. doi: [10.1371/journal.pone.0079309](https://doi.org/10.1371/journal.pone.0079309)
- Real-life data about the efficacy of diamagnetic therapy and its mechanism of action.**
- Ross CL, Ang DC, Almeida-Porada G. Targeting mesenchymal stromal cells/pericytes (MSCs) with pulsed electromagnetic field (PEMF) has the potential to treat rheumatoid arthritis. *Front Immunol.* 2019;10(MAR). doi: [10.3389/fimmu.2019.00266](https://doi.org/10.3389/fimmu.2019.00266)

12. Premi E, Benussi A, La Gatta A, et al. Modulation of long-term potentiation-like cortical plasticity in the healthy brain with low frequency-pulsed electromagnetic fields. *BMC Neurosci.* 2018;19(1):1–6. doi: [10.1186/s12868-018-0434-z](https://doi.org/10.1186/s12868-018-0434-z)
  - **Discussion about pain clinical scores to understand their reliability in clinical practice.**
13. Peng L, Fu C, Wang L, et al. The effect of pulsed electromagnetic fields on angiogenesis. *Bioelectromagnetics.* 2021;42(3):250–258. doi: [10.1002/bem.22330](https://doi.org/10.1002/bem.22330)
  - **Discussion about pain clinical scores to understand their reliability in clinical practice.**
14. Varani K, Vincenzi F, Ravani A, et al. Adenosine receptors as a biological pathway for the anti-inflammatory and beneficial effects of low frequency low energy pulsed electromagnetic fields. *Mediators Inflamm.* 2017;2017:1–11. doi: [10.1155/2017/2740963](https://doi.org/10.1155/2017/2740963)
15. Urnuksaikhan E, Mishig-Ochir T, Kim SC, et al. Neuroprotective effect of low frequency-pulsed electromagnetic fields in ischemic stroke. *Appl Biochem Biotechnol.* 2017;181(4):1360–1371. doi: [10.1007/s12010-016-2289-z](https://doi.org/10.1007/s12010-016-2289-z)
  - **Useful insights about degenerative cervical myelopathy.**
16. Thong ISK, Jensen MP, Miró J, et al. The validity of pain intensity measures: what do the NRS, Vas, VRS, and FPS-R measure? *Scand J Pain.* 2018;18(1):99–107. doi: [10.1515/sjpain-2018-0012](https://doi.org/10.1515/sjpain-2018-0012)
17. Bouhassira D, Attal N, Alchaar H, et al. Comparison of pain syndromes associated with nervous or somatic lesions and development of a new neuropathic pain diagnostic questionnaire (DN4). *Pain.* 2005;114(1):29–36. doi: [10.1016/j.pain.2004.12.010](https://doi.org/10.1016/j.pain.2004.12.010)
18. Apolone G, Mosconi P. The Italian SF-36 health survey. *J Clin Epidemiol.* 1998;51(11):1025–1036. doi: [10.1016/S0895-4356\(98\)00094-8](https://doi.org/10.1016/S0895-4356(98)00094-8)
19. Jannelli G, Nouri A, Molliqaj G, et al. Degenerative cervical myelopathy: review of surgical outcome predictors and need for multimodal approach. *World Neurosurg.* 2020;140:541–547. doi: [10.1016/j.wneu.2020.04.233](https://doi.org/10.1016/j.wneu.2020.04.233)
20. Hirayama Y, Mowforth OD, Davies BM, et al. Determinants of quality of life in degenerative cervical myelopathy: a systematic review. *Br J Neurosurg.* 2023;37(1):71–81. doi: [10.1080/02688697.2021.1999390](https://doi.org/10.1080/02688697.2021.1999390)
21. Yurac R, Matamala JM, Zamorano JJ, et al. Degenerative cervical myelopathy. *Rev Med Chil.* 2022;150(3):339–352. doi: [10.4067/S0034-98872022000300339](https://doi.org/10.4067/S0034-98872022000300339)
22. Purnell MC, Butawan MBA, Bingol K, et al. Modulation of endoplasmic reticulum stress and the unfolded protein response in cancerous and noncancerous cells. *SAGE Open Med.* 2018;6:2050312118783412. doi: [10.1177/2050312118783412](https://doi.org/10.1177/2050312118783412)
23. Kubat NJ, Moffett J, Fray LM. Effect of pulsed electromagnetic field treatment on programmed resolution of inflammation pathway markers in human cells in culture. *J Inflamm Res.* 2015;8:59–69. doi: [10.2147/JIR.S78631](https://doi.org/10.2147/JIR.S78631)
24. Miller SL, Coughlin DG, Waldorff EI, et al. Pulsed electromagnetic field (PEMF) treatment reduces expression of genes associated with disc degeneration in human intervertebral disc cells. *Spine J.* 2016;16(6):770–776. doi: [10.1016/j.spinee.2016.01.003](https://doi.org/10.1016/j.spinee.2016.01.003)
25. Chang K, Chang WHS. Pulsed electromagnetic fields prevent osteoporosis in an ovariectomized female rat Model: a prostaglandin E2-associated process. *Bioelectromagnetics.* 2003;24(3):189–198. doi: [10.1002/bem.10078](https://doi.org/10.1002/bem.10078)
26. Mert T, Yaman S. Pro-inflammatory or anti-inflammatory effects of pulsed magnetic field treatments in rats with experimental acute inflammation. *Environ Sci Pollut Res.* 2020;27(25):31543–31554. doi: [10.1007/s11356-020-09401-z](https://doi.org/10.1007/s11356-020-09401-z)
27. Ahmed Z, Wieraszko A. Pulsed magnetic stimulation modifies amplitude of action potentials in vitro via ionic channels-dependent mechanism. *Bioelectromagnetics.* 2015;36(5):386–397. doi: [10.1002/bem.21917](https://doi.org/10.1002/bem.21917)
28. Coşkun Ö, Naziroğlu M, Çömlekçi S, et al. Effects of 50 hertz-1 mT magnetic field on action potential in isolated rat sciatic nerve. *Toxicol Ind Health.* 2011;27(2):127–132. doi: [10.1177/0748233710381893](https://doi.org/10.1177/0748233710381893)
29. Fan J, Lee ZH, Ng WC, et al. Effect of pulse magnetic field stimulation on calcium channel current. *J Magn Magn Mater.* 2012;324(21):3491–3494. doi: [10.1016/j.jmmm.2012.02.073](https://doi.org/10.1016/j.jmmm.2012.02.073)
30. Hattapoğlu E, Batmaz İ, Dilek B, et al. Efficiency of pulsed electromagnetic fields on pain, disability, anxiety, depression, and quality of life in patients with cervical disc herniation: a randomized controlled study. *Turk J Med Sci.* 2019;49(4):1095–1101. doi: [10.3906/sag-1901-65](https://doi.org/10.3906/sag-1901-65)