

THE INFLUENCE OF GEOMAGNETIC ACTIVITY ON PAIN MANAGEMENT AND POST-OPERATIVE COMPLICATIONS: TECHNOLOGICAL CHALLENGES

Andro Atoshvili

*Georgian Technical University (GTU), Faculty of Informatics and Control Systems, Biomedical Engineering, PhD Program,
Academic Advisor: Nikoloz Invia, professor, GTU*

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Introduction: Recent 2026 evidence from the American Academy of Pain Medicine (AAPM) and leading peer-reviewed journals (*PAIN, Pain Medicine*) demonstrates that acute and chronic pain management has shifted beyond traditional monotherapy (opioid reliance) toward multimodal, non-opioid strategies and advanced interventional techniques. Pain perception is intrinsically linked to central nervous system maladaptation and neural network reorganization, particularly within the anterior cingulate cortex (ACC). The impact of external environmental triggers, specifically space weather and geomagnetic activity, on these bioelectric and structural neural pathways represents one of the most critical and under-researched technological challenges in modern biomedicine.

Objective: This study aims to evaluate the correlation between geomagnetic activity (measured by the Kp-index) and post-operative pain intensity, the efficacy of multimodal analgesia, and early post-operative complications, while establishing a technological framework for objective monitoring and clinical management.

Methods: This prospective observational study will include patients undergoing elective minimally invasive procedures or regional interventions (e.g., radiofrequency ablation - RFA, nerve blocks). Subjective pain trajectories and cognitive factors, such as mental defeat, will be captured digitally using Ecological Momentary Assessment (EMA) and VAS/NRS scales. To achieve objective quantification, cortical hyperexcitability and central pain sensitization will be tracked via **electroencephalography (EEG)** and transcranial **ultrasound stimulation**, while localized muscle hypertonicity will be measured via **surface electromyography (EMG)**. Multi-layered clinical datasets will be processed through artificial intelligence (AI) algorithms and cross-referenced with real-time geomagnetic metrics.

Expected Results: It is hypothesized that elevated geomagnetic activity days (when the te strength can reach maximum) will significantly correlate with increased neural network excitability (evidenced by EEG), muscle spasms (evidenced by EMG), and a higher incidence of subjective mental defeat. This cascade is expected to temporarily blunt the efficacy of standard non-opioid multimodal protocols, necessitating breakthrough technological neuromodulation (e.g., Spinal Cord Stimulation - SCS). Furthermore, the study will highlight the current technological gap in Electronic Health Record (EHR) systems regarding the lack of automated integration with space weather platforms.

Conclusion: This study addresses a profound technological barrier at the intersection of heliogeophysics and clinical algology. The findings will lay the groundwork for personalized, space-weather-adaptive neuromodulatory and pharmacological guidelines to optimize post-operative outcomes.