Masters Thesis Information Showcase
Spring Semester-2026
Year 2026

Department: Biomedical Engineering
Programme: Evening
Specialization: M.Engg. Biomedical Engineering

1	**Title of the Thesis** Aesthetic and Ergonomic Redesign of a Wearable Migraine Neuromodulation Device Using 3D CAD Tools
2	**Abstract** (min 300 to 500 words) Migraine is one of the most prevalent and disabling neurological disorders worldwide, affecting approximately 14% of the global population and imposing a substantial personal, social, and economic burden. In Pakistan, the prevalence of migraine exceeds the global average, while awareness, diagnosis, and access to advanced treatment technologies remain limited. Although pharmacological therapies are commonly used, their associated side effects and long-term limitations have encouraged the exploration of non-pharmacological alternatives such as neuromodulation. This thesis presents the aesthetic and ergonomic redesign of a wearable migraine neuromodulation device using three-dimensional Computer-Aided Design (3D CAD) and photorealistic rendering technologies. The work builds upon a previously developed functional prototype that combined transcranial direct current stimulation (tDCS) and vibration-based mechanical stimulation for migraine management. While the original device demonstrated promising therapeutic potential, it suffered from limitations related to comfort, fit, anatomical consistency, and visual appearance. The redesign process involved the analysis of the existing prototype, identification of ergonomic shortcomings, and incorporation of anatomically accurate electrode and massager placement based on relevant cranial nerve locations. A complete 3D CAD model of the device was developed, followed by photorealistic rendering to evaluate aesthetics, component integration, and overall usability prior to fabrication. The final prototype was fabricated using Lycra material and featured integrated component housing, internal cable routing, a retractable eye cover, improved weight distribution, and enhanced wearer comfort. The redesigned device was evaluated through preliminary clinical testing involving 27 participants, including chronic migraine patients, non-chronic migraine patients, healthy subjects, and a sham therapy subject. Assessment was conducted using validated outcome measures including the Migraine Disability Assessment (MIDAS), Headache Impact Test-6 (HIT-6), and Migraine Treatment Optimization Questionnaire (m-TOQ). Results demonstrated improvements in migraine-related disability, headache impact, and treatment satisfaction for most patients receiving active therapy. Chronic migraine patients showed particularly notable improvements, while the sham therapy subject exhibited no meaningful clinical change. The findings indicate that the application of 3D CAD methodologies can significantly improve the ergonomics, wearability, and user acceptance of wearable therapeutic devices. The redesigned migraine neuromodulation cap provides a low-cost, non-invasive, and

	clinically promising alternative for migraine management, particularly in resource-limited settings such as Pakistan, while establishing a strong foundation for future clinical and commercial development
3	**Impact on SDG#___"** (min 500 words) (Please mention the impact of the relevant attained SDG) **<u>Impact on SDG #3 – Good Health and Well-being</u>** This project directly contributes to Sustainable Development Goal (SDG) 3: Good Health and Well-being by developing a non-invasive wearable neuromodulation cap for migraine management. The device combines transcranial direct current stimulation (tDCS) and mechanical vibration therapy to provide a drug-free alternative that can reduce migraine-related disability, improve quality of life, and enhance treatment satisfaction. By offering a safe, comfortable, and accessible therapeutic solution, the project supports improved healthcare outcomes, particularly for individuals suffering from chronic migraine. **<u>Impact on SDG #9 – Industry, Innovation and Infrastructure</u>** The project aligns with Sustainable Development Goal (SDG) 9: Industry, Innovation and Infrastructure through the integration of 3D Computer-Aided Design (CAD), photorealistic rendering, and biomedical engineering to redesign an innovative wearable medical device. The use of advanced digital design methodologies improves ergonomics, manufacturability, and product quality while supporting the development of indigenous healthcare technologies. This innovation demonstrates the potential for translating academic research into commercially viable medical devices, strengthening local biomedical innovation and technological advancement.
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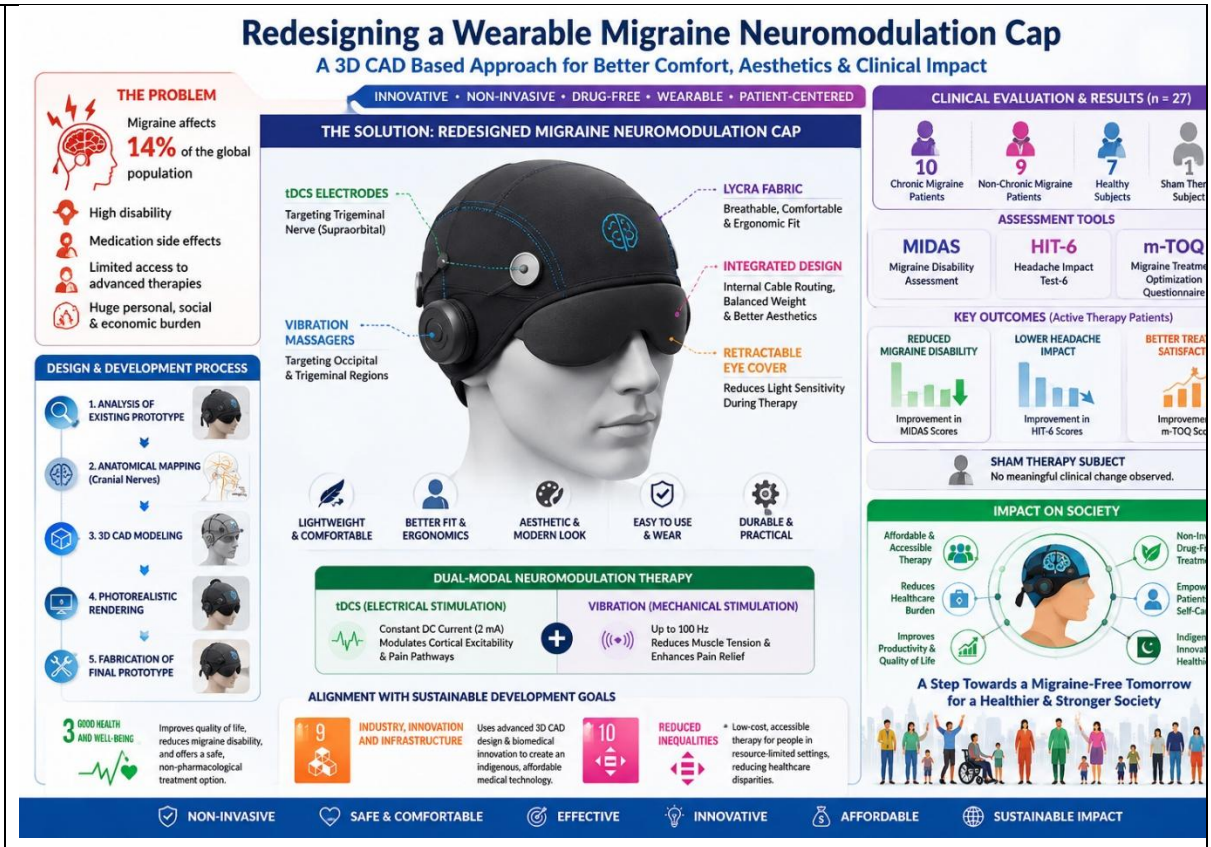
6	**Graphical Abstract**


Redesigning a Wearable Migraine Neuromodulation Cap
A 3D CAD Based Approach for Better Comfort, Aesthetics & Clinical Impact
THE PROBLEM
Migraine affects 14% of the global population
High disability
Medication side effects
Limited access to advanced therapies
Huge personal, social & economic burden
INNOVATIVE • NON-INVASIVE • DRUG-FREE • WEARABLE • PATIENT-CENTERED
THE SOLUTION: REDESIGNED MIGRAINE NEUROMODULATION CAP
tDCS ELECTRODES
Targeting Trigeminal Nerve (Supraorbital)
VIBRATION MASSAGERS
Targeting Occipital & Trigeminal Regions
LYCRA FABRIC
Breathable, Comfortable & Ergonomic Fit
INTEGRATED DESIGN
Internal Cable Routing, Balanced Weight & Better Aesthetics
RETRACTABLE EYE COVER
Reduces Light Sensitivity During Therapy
LIGHTWEIGHT & COMFORTABLE
BETTER FIT & ERGONOMICS
AESTHETIC & MODERN LOOK
EASY TO USE & WEAR
DURABLE & PRACTICAL
DESIGN & DEVELOPMENT PROCESS
1. ANALYSIS OF EXISTING PROTOTYPE
2. ANATOMICAL MAPPING (Cranial Nerves)
3. 3D CAD MODELING
4. PHOTOREALISTIC RENDERING
5. FABRICATION OF FINAL PROTOTYPE
DUAL-MODAL NEUROMODULATION THERAPY
tDCS (ELECTRICAL STIMULATION)
Constant DC Current (2 mA) Modulates Cortical Excitability & Pain Pathways
VIBRATION (MECHANICAL STIMULATION)
Up to 100 Hz Reduces Muscle Tension & Enhances Pain Relief
CLINICAL EVALUATION & RESULTS (n = 27)
10 Chronic Migraine Patients
9 Non-Chronic Migraine Patients
7 Healthy Subjects
1 Sham Ther Subject
ASSESSMENT TOOLS
MIDAS Migraine Disability Assessment
HIT-6 Headache Impact Test-6
m-TOQ Migraine Treatme Optimization Questionnaire
KEY OUTCOMES (Active Therapy Patients)
REDUCED MIGRAINE DISABILITY
Improvement in MIDAS Scores
LOWER HEADACHE IMPACT
Improvement in HIT-6 Scores
BETTER TREA SATISFACT
Improveme m-TOQ Sco
SHAM THERAPY SUBJECT
No meaningful clinical change observed.
IMPACT ON SOCIETY
Affordable & Accessible Therapy
Reduces Healthcare Burden
Improves Productivity & Quality of Life
Non-In Drug-F Treatm
Empow Patient Self-Ca
Indigen Innovat Healthc
A Step Towards a Migraine-Free Tomorrow for a Healthier & Stronger Society
ALIGNMENT WITH SUSTAINABLE DEVELOPMENT GOALS
3 GOOD HEALTH AND WELL-BEING
Improves quality of life, reduces migraine disability, and offers a safe, non-pharmacological treatment option.
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
Uses advanced 3D CAD design & biomedical innovation to create an indigenous, affordable medical technology.
10 REDUCED INEQUALITIES
* Low-cost, accessible therapy for people in resource-limited settings, reducing healthcare disparities.
NON-INVASIVE
SAFE & COMFORTABLE
EFFECTIVE
INNOVATIVE
AFFORDABLE
SUSTAINABLE IMPACT