Transcutaneous Electrical Nerve Stimulation (TENS) for Pain Alleviation in Perioperative Fracture Patients

Specific Aims:

Opioid overdoses continue to increase, and the path to addiction often begins with a prescription. Half of postoperative patients receive an opioid prescription.[1] Multimodal pain management, including cognitive, physical, and pharmaceutical strategies, reduces reliance on opioids alone. Transcutaneous nerve stimulation (TENS) is one physical strategy; this study aims to evaluate the effectiveness of TENS as part of postoperative pain management.

Specific Aim 1: To pilot the use of TENS among a postoperative lower extremity injury population as part of multimodal pain management.

H_0: TENS cannot be delivered safely among this population.

H_A: TENS can be delivered safely among this population.

Specific Aim 2: To compare utilization of inpatient and outpatient pain medications of patients treated with TENS and historical controls.

H_0: Patients treated with TENS will require the same amount of opioids as historical controls.

H_A: Patients treated with TENS will require less opioids (lower morphine milligram equivalent – MME) than historical controls during hospitalization and throughout 3-month follow up.

Specific Aim 3: To compare patient-reported outcomes of patients treated with TENS and historical controls.

H_0 1: Patients treated with TENS will experience equivalent patient-reported outcomes as compared to historical controls.

H_A 1: Patients treated with TENS will experience greater improvement in patient-reported outcomes (PROMIS 29) relative to baseline as compared to historical controls.

H_0 2: Patients treated with TENS will report higher pain scores as compared to historical controls.

H_A 2: Patients treated with TENS will report equivalent or lower pain scores as compared to historical controls.

Background and Significance:

Transcutaneous electrical nerve stimulation (TENS) is an affordable and non-invasive option for post-operative analgesia. Broadly, TENS devices deliver pulsed electrical impulses across skin to modulate pain. They are theorized to work through different mechanisms at multiple physiologic levels. Centrally, TENS units activate small-diameter sensory afferents (Aδ nerve fibers), which in turn activate descending pain-inhibitory networks. Peripherally, TENS activation of both large- and small-diameter sensory afferents blocks nociceptive signals to the

brain and is instead perceived as TENS-induced paresthesias. Finally, TENS efficacy may also be mediated by μ-opioid, 5HT-1, and 5HT-2 receptors, particularly at low-frequency electrical activity.[2]

There are inconclusive results for the adjunctive use of TENS to modulate pain, largely because of a relative paucity of high-quality trials and significant inter-study heterogeneity due to non-standardized protocols. Moreover, most studies within the orthopaedic literature have been concentrated primarily within the total knee arthroplasty (TKA) literature and may have limited generalizability to orthopaedic trauma patients. Some studies have shown a trend towards decreased opioid consumption with the adjunctive use of TENS (vs. placebo-TENS or standard care)[3,4] while other studies have shown no difference in pain scores in the post-operative period.[5-8] To our knowledge, only two recent RCTs have been conducted on non-TKA orthopaedic populations, both of which show promise for the use of TENS postoperatively. One prospective double-blind randomized trial on arthroscopic rotator cuff repairs found a 25% reduction in post-operative opioid consumption when TENS was used adjunctively for pain control .[9] Another single-blind prospective RCT on Colles' fractures reported greater postoperative pain improvements in patients receiving TENS vs. placebo.[10]

There is a growing body of evidence to suggest that TENS therapy can reduce post-operative pain after orthopedic procedures. More high-quality studies are needed to strengthen this suggestion and to characterize specific protocols, populations, and orthopedic conditions for which it might work best. Transcutaneous electrical nerve stimulation, if shown to be effective, stands to serve as an affordable non-opioid, non-invasive option for the safe and effective treatment of pain in the orthopaedic trauma patient population.

TENS units are a non-significant risk device and, therefore, do not require an IDE based upon FDA guidance.[15-17] The sensor pads will be placed at the same time as the surgical fixation of the study injury. It does not present a potential serious risk to the health and welfare of patients.

Research Design and Method:

Overall Design

This will be a prospective observational study of patients undergoing operative treatment of lower extremity conditions, including fracture fixation, treatment of nonunion, and deformity correction. The study will be conducted at a single Level I trauma center. Enrolled patients will receive TENS postoperatively during hospitalization; TENS units will also be sent home with patients for use throughout recovery. This group will be compared to controls injury-matched from a prospectively collected, historical database on mobility who did not receive treatment with TENS.

Inclusion Criteria:

- Operative treatment of lower extremity conditions, including fracture fixation, treatment of nonunion, and deformity correction
- Injury or deformity of the femur, tibia (plateau, shaft, pilon), or hindfoot and ankle
- Isolated injury
- 18 years or older
- Able to provide consent

- Plan for discharge to home

Exclusion Criteria:

- under 18 years of age
- Unable to provide consent (no use of LAR)
- History of dementia or Alzheimer's disease
- Patient residing in a residential care facility prior to admission (i.e, skilled nursing facility, nursing home, assisted living facility)

Treatment Groups:

The prospectively enrolled patients will have TENS pads placed immediately following surgery, prior to PACU. The TENS unit will be connected to the pads and turned on in the PACU. Each patient will receive instructions for suggested use of the device. They will be allowed to individualize the frequency/amplitude of the current to reach a "strong sub-noxious" stimulation, as recommended by previous studies.[11,12] They will be asked to aim for 4x45 minute sessions each day. This protocol was previously published by a separate group demonstrating decreased post-operative pain levels with adjunctive TENS use.[8]

This institution has an ongoing research study which collects injury characteristics, patient-reported outcomes, and kinematic/performance data for orthopaedic trauma patients with lower-extremity injuries. Patients with similar injuries as the prospectively enrolled patients will be identified in this database to serve as controls, because TENS units were not previously used at this institution for pain management. Our institution also has a database of all opioid prescriptions as well as risk factors that can be used to provide these data for the controls.[13]

Sample Size:

The sample size estimate was based on data from the meta-analysis conducted by Tedesco et al[2]. This is a superiority prospective observational study with matched historical controls and the primary outcome variable is morphine milligram equivalents (MME) within the first 48 hours postoperatively. The assumed mean MME for the TENS group is 6.4 and 9.9 for the control group with a pooled standard deviation of 5.5. Using a two-sided independent T-test, .05 level of significance and 80% power, 40 patients per group is needed for a total study sample of 80 patients. Therefore, we will enroll 50 patients in order to account for loss to follow-up. Historical controls will be injury-matched from a prospectively collected, historical database on mobility (N=50).

Outcome Measures:

Primary Outcomes: The primary outcome will be inpatient and outpatient opioid use, defined as morphine milligram equivalents. Morphine milligram equivalent dose (MME) will be calculated to standardize across different medications. Pill counts will be conducted at follow-up visits to account for unused opioids, and patients will be provided with opioid disposal kits. Use of non-opioid pain medications (i.e. NSAIDS, acetaminophen, gabapentin) will be documented. Patients will also be asked about their use of nonpharmaceutical modalities at each follow-up visit or phone call, including cryotherapy, aromatherapy, and cognitive strategies.

Secondary Outcomes: The secondary outcomes will be patient-reported outcomes, measured by the PROMIS 29[14], which includes physical function, anxiety, depression, fatigue, sleep disturbance, ability to participate in social roles and activities, pain interference and pain intensity. In addition, pain scores from the inpatient stay and clinic visits will be abstracted from the medical record. PROMIS will be administered during the hospitalization and at follow-up visits or via phone calls, emails, or text messages at 2, 6, and 12 weeks. VAS pain scores will be abstracted from the medical record during the hospitalization and at each follow-up visit.

Process Measures and Feasibility: Process measures will be collected to document feasibility of implementing TENS postoperatively among this patient population, including: patient compliance with TENS after discharge, number of times each day TENS was used, duration of each TENS session, and average frequency/amplitude of electrical current for each patient.

Study Procedures:

Screening & Enrollment: All patients 18 years or older presenting for initial treatment, nonunion or limb length deformity correction of the femur, tibia (plateau, shaft, pilon), or hindfoot/ankle will be screened for eligibility. Once eligibility has been confirmed, a research coordinator and/or investigator will approach patient for consent prior to surgery. Patients will be given the opportunity to review the informed consent document and ask questions about the study. The informed consent will comply with the ICH/GCP regulatory guidelines.

Baseline: Once consent is obtained, baseline data regarding participant characteristics, injury characteristics and PROMIS scores will be collected from the participant and entered into the electronic data collection system. Data will also be collected from the medical record regarding injury characteristics, fracture fixation, pain scores and utilization of pain alleviation modalities (pharmaceutical and nonpharmaceutical).

Follow-up: Participants will complete study visits at 2, 6, and 12 weeks following admission to the hospital, which may overlap with regularly scheduled standard of care clinic visits. These visits may also be completed via phone calls, text messages, or email. At these visits, participants will be asked to complete PROMIS-29 survey. Data regarding use of any pharmaceutical and nonpharmaceutical modalities for pain management will be collected at these visits. Additional variables about fracture complications will be collected from the electronic medical record.

Adverse Reporting

All adverse event will be reported accordance with the local IRB rules. The principal investigator must classify the event as Related, Probably Related, Possibly Related or Not Related.

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