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Technical notes & surgical techniques

Non-invasive trial testing for trigeminal branch stimulation to treat refractory trigeminal neuropathic pain: A technical note

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ABSTRACT

Objective: Trigeminal neuropathic pain can be debilitating and extremely difficult to treat. Trigeminal branch stimulation is a minimally invasive treatment that has shown benefit in earlier series. However, there is currently no widely accepted method to predict response. We propose an office-based, non-invasive trial to assess potential pain relief before the final decision for electrode implantation in patients with refractory trigeminal neuropathic pain.

Methods: We retrospectively reviewed patients undergoing transcutaneous trigeminal branch nerve stimulation testing before moving on to electrode implantation between 2009 and 2017. Testing was done using an Ojeman Cortical Stimulator (OCS1) or a Grass S-88 Nerve/Muscle Stimulator via two SIU-7 CC isolators over the painful area. Frequency, pulse width and amplitude were set at values consistent with implanted electrode settings. Patients reporting more than 50% relief after up to 2 h of stimulation, and loss of relief after stimulation was discontinued, were deemed appropriate candidates and subsequently underwent implantation.

Results: We identified 7 patients undergoing testing and subsequent implantation. Follow-up ranged from 2 months to 8 years. During last follow-up, 4 patients were still using their systems. Electrode removal was necessary because of loss of efficacy or infection. Three patients still using their systems required revision. Initial visual analogue pain score (VAS) ranged between 8 and 10. Patients with systems still in use reported VAS 1–4 on last follow-up, with pain relief of about 70%.

Conclusions: Transcutaneous office-based testing is a simple and cost-effective method to gauge response to trigeminal branch stimulation in patients with refractory trigeminal neuropathic pain.

1. Introduction

Trigeminal neuropathic pain is a potentially debilitating condition that may be refractory to multiple treatment modalities. While some patients have been reported to respond to implantation and stimulation of electrodes within the subcutaneous tissues of the face near receptor fields of trigeminal branch nerves, factors contributing to which patients are likely to respond to such a modality has not yet been elucidated. Previous studies have described utilizing temporary placement of the subcutaneous electrodes with externalized systems, to test response over a period of weeks [1]. Such practices have the potential for infections and scar formation. Therefore, we have opted for a non-invasive, cost-effective, office-based trial, where electrodes are placed directly on the patient's skin for up to two hours to assess response. Since no implantation is done for the trial, there is no potential for infections and we have observed no other complications, as well as a decrease in cost and better time-efficacy. We review and describe here this trial technique and our outcomes in order to provide an easier and safer way to predict which patients with refractory trigeminal neuropathic pain are most likely to benefit from implanted stimulation.

2. Materials and methods

2.1. Patient selection

A retrospective review of patients that underwent superficial electrode testing and subsequent implantation in our institution by the Principal Investigator (JA) for the diagnosis of refractory trigeminal neuropathic pain was conducted in the period between 2009 and 2017. The following information was obtained from the medical records:

Abbreviations: IRB, Institutional Review Board; F, female; M, male; MVD, microvascular decompression of the trigeminal nerve; OSC, Ojeman Cortical Stimulator; PIFP, persistent idiopathic facial pain; RF, radiofrequency; VAS, visual analogue pain score

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patient age, sex, date of procedure, date of last follow-up, visual-analogue pain score (VAS) on presentation, after testing and on last follow-up, pertinent past medical history, clinical condition on presentation and follow-up, and complications of the procedure. The patients were also contacted by phone to be formally consented for inclusion to the study, and to be questioned about their current VAS and their overall satisfaction with the procedure. The study question was: Can office-based superficial electrode trial predict long-term pain outcome in patients undergoing facial stimulation for refractory trigeminal neuropathic pain? To assess the predictive value of office-based testing, we investigated the association between VAS improvement after office-based surface electrode testing and VAS improvement on last follow-up. Institutional Review Board (IRB) approval was obtained prior to commencement of the study. Patient consent was sought and obtained during the follow-up phone call.

2.2. Trial testing

Each patient came into our clinic as for a typical office visit. The region of most intense pain, or the clear origin of the pain was, again, described by the patient. Adhesive electrodes (Boston Scientific, Marlborough, MA, USA) were then secured to the skin to bracket this area as if in line with the trajectory of a percutaneous lead placed from the pre-auricular area to the furthest medial point of pain (Fig. 1). Adding tape or having the patient gently press the electrode to their skin during the stimulation was used whenever it was difficult to keep the electrode adherent to the skin (e.g. a nasal branch region). The wires from the electrode were then plugged into the connector wires that had been modified to plug into the Ojemann stimulator (Fig. 2, Integra Lifesciences, Plainsboro Township, NJ, USA) or the Grass S-88 amplifier/stimulator (Astro-Med Inc., West Warwick, RI, USA). Either way, once ready, settings of frequency and pulse width are set to typical settings used clinically (e.g. 60 Hz, 200 μS). Amplitude is slowly increased, asking the patient if they feel it and whether it is comfortable or not. The patient should determine the ideal level of intensity to leave the settings for a short period of time (perhaps 10–15 min) while the patient also determines whether it is helping the pain.

2.3. Electrode implantation

After a positive trial period, the implantation of the permanent system (Boston Scientific, Marlborough, MA, USA) was performed at a later date under general anesthesia. The target area was prepared and draped in a sterile fashion. Pre-operative antibiotics were always given by protocol. A small skin incision was made in the pre-auricular area behind the hairline and above the zygoma. An 8-contact percutaneous electrode was placed traversing the subcutaneous tissue from the incision laterally to medial target regions using an Epimed needle (Epimed International, Inc., Johnstown, NY, USA) with the plastic stylet, so that the needle could be pre-bent to custom features and the stylette will still be easily removable. The painful area is mapped in the pre-operative holding area very precisely, marked with a skin marker, and the plan for electrode positioning carefully thought out. Each lead is then anchored with a 2–0 silk suture to a deeper fascial or soft tissue area twice about 1 cm apart without a silicone anchor cover in order to minimize bulk under the skin layer and prevent some of the increased likelihood of erosions in these devices. Typically, the IPG site is then created in the subclavicular area and the leads tunneled from the anchored area to the IPG site and connected to the IPG. Impedance testing is performed and then the IPG is placed into its pocket and the incisions are closed. Most patients go home the same day and have some basic programs given in the recovery area before discharge and then fine-tuned on subsequent visits as necessary.

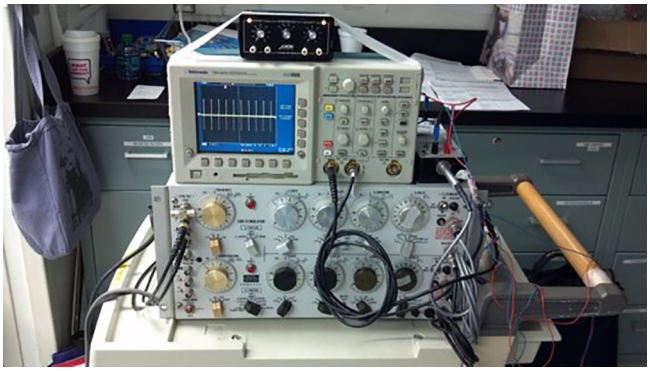

Fig. 2. Ojemann stimulator (Integra Lifesciences, Plainsboro Township, NJ, USA). After securing the electrodes on the patient's skin, the wires from the electrode were then plugged into the connector wires that had been modified to plug into the Ojemann stimulator. Settings of frequency and pulse width were then set to typical settings used clinically (e.g. 60 Hz, 200 μS). The amplitude was gradually increased until the patient identified an area that is comfortable. When the ideal settings were identified by the patient, stimulation was continued for 10–15 min before conclusion of the testing.

2.4. Follow-up and outcome analysis

The patients were scheduled to return to the outpatient clinic after 10 days post-implantation. During this visit they had their sutures removed, wound was examined, and the therapeutic effect was evaluated, resulting in any necessary adjustments in stimulation parameters. Afterwards, follow-up was determined on a case-by-case basis. Regardless of length of follow-up, all patients were called at the time of the study for a phone interview about current pain intensity, complications, change in medications, and satisfaction from the procedure. As our main goal was to describe the technique and present preliminary data, statistical tests were not be performed. Instead, descriptive

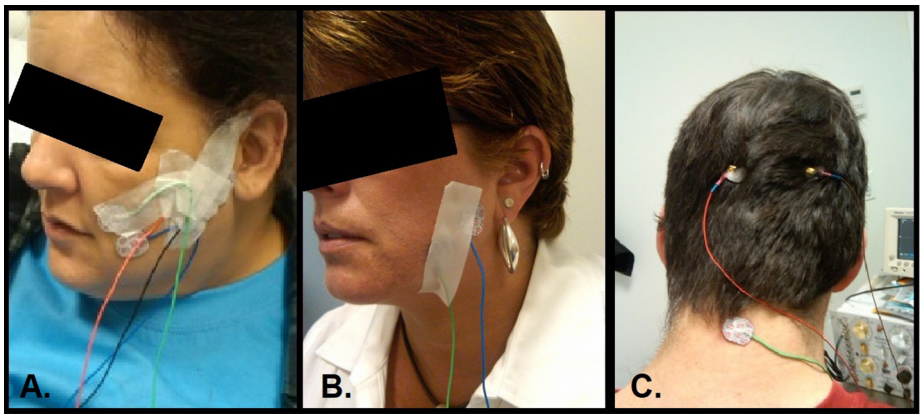

Fig. 1. Technique of office-based percutaneous electrode testing. After a thorough clinical evaluation, the area with the most intense pain was identified. Adhesive electrodes were then secured to the skin in the identified area: (A) in the V2 distribution, (B) in the V3 distribution, (C) in the occipital nerve distribution. In many cases, tape was used to further secure the electrodes on the patient's skin (A, B), whenever it was difficult for it to adhere to the skin.

statistics are presented. Microsoft Excel software (2019) was used for all data handling and presentation.

3. Results

Seven patients undergoing superficial testing and subsequent subcutaneous electrode implantation for intractable facial pain between 2009 and 2017 were identified for this study. One was male and six were female; mean age was 54.3 years (range 41–75 years). Distribution of facial pain in the patients were as follows: four had pain localized to the V1 distribution (supraorbital nerve and branches), one had V2 (infraorbital or superior alveolar branch) pain, one had pain covering both V1 and V2 regions, and for one patient we could not adequately localize the pain to one clear distribution. All patients had failed prior complex medical, or interventional treatments including microvascular decompression, radiofrequency ablation, and/or nerve blocks. Preoperative VAS pain scores ranged from 8 to 10, with a mean of 9.1. One of the patients had a neurovascular cause of her pain, which had failed multiple treatment modalities. Two patients had post-traumatic and two had post-herpetic trigeminal neuropathies, refractory to all other treatments attempted. The two remaining patients had cryptogenic causes which we could not adequately identify, likely classified as persistent idiopathic facial pain (PIFP). Detailed patient characteristics at baseline are presented in Table 1.

Patient follow-up ranged from 19 months to 119 months. During last follow-up, 4 patients (57%) still had at least 70% pain relief compared to their baseline. All of these patients had also experienced at least 70% relief after their trial superficial electrode testing session described herein, correctly predicting the long-term efficacy of the system. Good satisfaction with the device was in reported in all but one of these patients, who experienced painful wiring shortly after the procedure and had to remove the system soon after. The three remaining patients had less than 70% improvement on last follow-up. Two of these patients had had 90% improvement in their trial. However, both of these patients had their systems removed before their last follow-up, so we could not accurately assess their last long-term pain, though they had had improvement earlier on with the therapy. The last patient reported 50% relief during the trial and 30% benefit at last follow-up, but she was satisfied with the procedure overall. Patient-reported pain intensity preoperatively and after trial and long-term follow-up are presented in Table 2, while complications and lead removal cases are presented in Table 3.

4. Discussion

Trigeminal neuropathic pain is a refractory debilitating condition that greatly interferes with quality of life, posing significant challenges for both patients and treating physicians [2]. While more typical trigeminal neuralgia syndromes often respond to conventional treatments including microvascular decompression or radiofrequency thermocoagulation of the trigeminal ganglion [3,4], refractory trigeminal branch pain almost never improves following these procedures, and may worsen, leaving these patients with limited treatment options. Intrafacial stimulation holds out promise for long-term, reversible and programmable therapy without addictive medication or high-risk ablative procedures [5,6]. However, to date, there is no reliable way to predict the efficacy extent of this approach in each individual patient other than placing temporary leads while externalizing them for days. In this technical report, we propose a quick, office-based, non-invasive method to assess possible pain relief before the final decision for electrode implantation in patients with refractory trigeminal neuropathic pain. Similar to that of a transcutaneous electrical nerve stimulation therapy [7], currently used as an adjuvant to first-line medical treatment, behavioral therapy or nerve blocks.

Currently, methods to evaluate patient response include subcutaneous placement of electrodes as a trial previous to permanent

Table 1
Patient baseline characteristics.

Case	Age	Sex	VAS before	Affected branch(es)	Etiology	MVD	RF ablation	Nerve block	Pain Medication Preoperatively
1	60	F	9	V1, left	Post-traumatic	No	No	Yes	Duloxetine 30 mg/day
2	47	F	10	V1, left	Cryptogenic	No	No	Yes	Hydromorphone 8 mg/day
3	49	F	10	diffuse	Cryptogenic	No	No	Yes	Gabapentin 800 mg/day, Methadone 10 mg/day
4	41	F	9	V2, left	Post-herpetic	No	No	Yes	Topiramate 100 mg/day, Fluoxetine 20 mg/day, Buproprion 150 mg/day
5	75	F	8	V1, left	Post-herpetic	No	No	Yes	Gabapentin 300 mg/day, Oxycodone 20 mg/day, Nortriptyline 20 mg/day, Diclofenac topical gel
6	60	M	8	V1, left	Post-traumatic	No	No	Yes	Baclofen 20 mg/day, Duloxetine 60 mg/day, Pregabalin 300 mg/day, Tizanidine 4 mg/day
7	48	F	10	V1, V2, left	Neurovascular	Yes	Yes	Yes	Hydromorphone 36 mg/day, Topiramate 200 mg/day, Pregabalin 100 mg/day, Carbamazepine 200 mg/day

Abbreviations: VAS: visual analogue pain scale, MVD: microvascular decompression of the trigeminal nerve, RF: radiofrequency, F: female, M: male.

Table 2
Patient-reported pain intensity before and after the trial and final electrode implantation.

Case	VAS before	VAS after trial	Trial Pain Relief	VAS after implantation	Implantation Pain Relief	Self-Reported Satisfaction	Medication	Follow-up, months
1	9	1	90%	9	0%	No	Medication-free	119
2	10	3	70%	3	70%	Yes	Medication-free	101
3	10	0	100%	0	100%	No	No change	97
4	9	1	90%	9	0%	No	Medication-free	47
5	8	4	50%	6	30%	Yes	No change	39
6	8	2	80%	2	80%	Yes	Dose reduction	24
7	10	3	70%	1	90%	Yes	Dose reduction	19

Abbreviations: VAS: visual analogue pain scale.

Table 3
Procedure-related outcomes and complications.

Case	Times reprogrammed	Time to reprogramming, months	Times battery changed	Time to battery change, months	Complication	Lead removal	Time to lead removal, months	Reason for removal
1	2	6	Never		Yes	Yes	107	Painful wiring
2	1	6	1	60	Yes	No		
3	0		Never		Yes	Yes	37	Painful wiring
4	2	4	Never		No	Yes	8	Increasing pain
5	1	9	Never		Yes	No		
6	0		Never		No	No		
7	1	0	Never		Yes	No		

implantation [8]. This varies in terms of length in which patients are left with the transcutaneous electrodes, and if there is use of extension leads [9]. In a series of 8 patients, Jacob et al. reported their 90% response (i.e. reduction of more than 50% in the VAS) in patients that underwent test trial with a subcutaneous placement of electrodes for trial stimulation. They highlighted the potential of bias resulting due to short-term assessment; however, our technique is performed over a 2-h period, arguably enough for the patient to evaluate true effectiveness of our technique. Other disadvantages of such technique including its invasiveness, risk of infection, the possibility of delayed wound healing and even scar tissue generated by the electrode placement, which might modify patient response to the permanent implant [1].

Fortunately, pain aggravation from the simulation is usually detected quickly, and might require adjustment of several settings (either frequency or pulse width or both) along with brief trials for long-term trails to be adapted. Furthermore, it is not uncommon to require adjusting the positioning of the electrodes on the skin as well. This type of empirical adjustment with external stimulation almost always results in obvious clinical benefit in this relatively brief clinical setting – ostensibly for two reasons: first, the relatively superficial location of the target nerve to the skin surface, avoiding the need for high amplitudes which, in itself, could lead to motor simulation or discomfort side effects.

Secondly, the virtually constant pain that these patients experience allows them to readily discern if the pain was abated in a brief window of time without requiring discharge with a device from the clinical setting. Occasionally, suboptimal benefit is provided in the first visit, requiring scheduling of a second visit to better predict the potential effectiveness of the therapy. Finally, the perceived benefit to the patient might become more apparent to the patient once the therapy is discontinued. This may also be considered a positive trial.

5. Conclusions

Transcutaneous office-based testing provides a simple and cost-efficient method to gauge response to trigeminal branch stimulation in patients with refractory trigeminal neuropathic pain. Further research may better individualize therapy in this setting. Our technique demonstrates similar results in terms of responsiveness, and at the same time avoids potential facial scarring, cosmetic defects, and the previously mentioned risks of performing a subcutaneous trial. The authors consider the proposed technique to be simple and an aid in clinical decision making for this therapy.

Previous presentation

This work was previously presented as a Poster at the Annual Meeting of the American Association of Neurological Surgeons in April 2019 at San Diego, CA, USA.

Disclosures

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CRediT authorship contribution statement

Georgios A. Maragkos: Conceptualization, Formal analysis, Methodology, Writing - original draft. **Santiago Gomez-Paz:** Data curation, Formal analysis, Writing - original draft. **Mohamed M. Salem:** Data curation, Writing - original draft. **Patricia Baum:** Data curation, Project administration, Resources. **Jeffrey Arle:** Conceptualization, Investigation, Methodology, Supervision, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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