Motor cortex stimulation

Intracranial neurostimulation for pain relief is most frequently delivered by stimulating the motor cortex, the sensory thalamus, or the periaqueductal and periventricular gray matter.

Indications

The stimulation of these sites through MCS (motor cortex stimulation) and DBS (deep brain stimulation) has proven effective for treating a number of neuropathic and nociceptive pain states that are not responsive or amenable to other therapies or types of neurostimulation.

However, the mechanisms and outcome predictors still represent major challenges.

MCS has shown particular promise in the treatment of trigeminal neuropathic pain and central pain syndromes such as thalamic pain syndrome.

Motor Cortical Electrostimulation for Parkinson's disease

Motor Cortical Electrostimulation for Parkinson's disease

---

see Subdural motor cortex stimulation

Systematic Reviews

A systematic literature review was conducted using the search words “motor cortex stimulation and pain and neurosurgery” and “motor cortex stimulation and pain and quality of life.” Quality of life in our clinical trial was investigated in a series of 10 patients with chronic neuropathic pain prospectively followed for 12 mo after MCS.

Two hundred eighteen nonreplicated articles were pooled for analysis. Of these, 6 described measures of quality of life in the pre- and postoperative period. In these studies, 64 patients with different clinical conditions associated with neuropathic pain were followed for 6 to 84 mo after MCS surgery. Improvement in quality of life ranged from 35% to 85%. In our clinical series, visual analog scale (VAS), SF-12 physical (PhysCS), and mental scores (MenCS) recorded 12 mo after MCS were improved by 60 ± 10% (P = .002), 50 ± 13% (P = .002), and 22 ± 6% (P = .01), respectively. No significant correlation was found between postoperative improvement in pain and either PhysCS (r = 0.18; P = .6) or MenCS (r = -0.24; P = .5).

MCS improves quality of life in patients with chronic refractory neuropathic pain. Additional factors other than a simple analgesic effect may contribute to these results [1)].

Case series

2016

The significance of motor cortex stimulation (MCS) in chronic trigeminal neuropathic pain (TNP) syndromes remains unclear. Different techniques are performed worldwide in regard to operative procedure, stimulation parameters, test trials, and implanted materials.

The implantation of epidural leads over the motor cortex was performed via a burr hole technique with neuronavigation and intraoperative neurostimulation. Special focus was placed on a standardized test trial with an external stimulation device and the implementation of a double-blinded or placebo test phase to identify false-positive responders.

A total of 36 patients with TNP were operated on, and MCS was performed. In 26 of the 36 patients (72%), a significant pain reduction from a mean of 8.11 to 4.58 (on the visual analog scale) during the test trial was achieved ($P < .05$). Six patients were identified as false-positive responders (17%). At the last available follow-up of 26 patients (mean, 5.6 years), active MCS led to a significant pain reduction compared with the preoperative pain ratings (mean visual analog scale score, 5.01; $P < .05$).

MCS is an additional therapeutic option for patients with refractory chronic TNP, and significant long-term pain suppression can be achieved. Placebo or double-blinded testing is mandatory [2].

2015

Twenty patients were implanted with MCS electrodes at the Burdenko Neurosurgical Institute in the period between 2004 and 2014. The mean age of patients was 52 years (26 to 74 years). The patients suffered from neuropathic pain syndromes of different genesis (post-stroke, multiple sclerosis, atypical facial pain, phantom limb pain, brachial plexus injury, spinal cord injury, complex regional pain syndrome I). All patients underwent neurological examination with verification of neuropathic pain (DN4, Pain Detect, LANSS). The pain intensity and its effect on quality of life were assessed before operation and during follow-up according to 10-point visual-analog scales (modified Brief Pain Inventory). Before surgery, all patients underwent several repetitive transcranial magnetic stimulation (rTMS) sessions. After implantation of epidural electrodes, test MCS was performed.

Test stimulation was positive in 19 (95%) patients. All these patients were implanted with a chronic MCS system. The mean follow-up was 49.3 months (from 3 to 96 months). In short-term follow-up (fist 6 months), a positive result of MCS was observed in 17 patients, and a reduction in the pain intensity ranged from 37.5% to 90%. In long-term follow up (from 12 to 96 months), 14 patients had positive MCS RESULTS: and a reduction in the pain intensity amounted to 25% to 60%. All patients with positive MCS results received significantly decreased doses of opioids and tramadol. Two patients developed infectious complications, but there was no neurological deficit. Analysis of the factors affecting the efficacy of motor cortex stimulation did not reveal a statistically significant effect of rTMS and the presence and intensity of motor deficit.

Chronic epidural MCS is an effective and safety method for the treatment of some chronic neurogenic medically-refractory pain syndromes. Further research is necessary to specify the patient selection criteria and the MCS efficacy predictors [3].

2014

In eight cases, including neuropathic pain syndromes of trigeminal or thalamic origin with or without anesthesia dolorosa. Pain relief was evaluated on the basis of comparison of Visual Analog scores at baseline and at 3 months after surgery. In addition, they assessed differences in pain relief outcomes between cases with trigeminal neuralgia and thalamic stroke, as well as cases with or without anesthesia dolorosa (i.e. pain with numbness of the affected area). Visual Analog Scale scores showed a statistically significant decrease of 4.19 (P=0.002) at 3 months follow-up compared with baseline. Pain relief levels in four of five patients in the subgroup with facial pain were higher than 50%, and none of the patients in the subgroup with thalamic and phantom limb pain showed such a good outcome. Furthermore, they found larger pain relief levels in facial pain conditions with versus without anesthesia dolorosa. These results point to utility of motor cortex stimulation in relieving neuropathic pain, as well as better outcomes for patients with facial pain and anesthesia dolorosa. Future studies should incorporate methods to noninvasively trial those patients who may benefit from surgical implantation to predict the outcomes and maximize their negative predictive value [4)].

2009

Sixteen patients were included with pain origin as follows: trigeminal neuralgia (n = 4), brachial plexus lesion (n = 4), neurofibromatosis type-1 (n = 3), upper limb amputation (n = 2), herpes zoster ophthalmicus (n = 1), atypical orofacial pain secondary to dental extraction (n = 1) and traumatic nerve trunk transection in a lower limb (n = 1). A quadripolar lead was implanted, under radiological and electrophysiological guidance, for epidural cortical stimulation. A randomized crossover trial was performed between 1 and 3 months postoperative, during which the stimulator was alternatively switched 'on' and 'off' for 1 month, followed by an open phase during which the stimulator was switched 'on' in all patients. Clinical assessment was performed up to 1 year after implantation and was based on the following evaluations: visual analogue scale (VAS), brief pain inventory, McGill Pain questionnaire, sickness impact profile and medication quantification scale. The crossover trial included 13 patients and showed a reduction of the McGill Pain questionnaire-pain rating index (P = 0.0166, Wilcoxon test) and McGill Pain questionnaire sensory subscore (P = 0.01) when the stimulator was switched 'on' compared to the 'off-stimulation' condition. However, these differences did not persist after adjustment for multiple comparisons. In the 12 patients who completed the open study, the VAS and sickness impact profile scores varied significantly in the follow-up and were reduced at 9-12 months postoperative, compared to the preoperative baseline. At final examination, the mean rate of pain relief on VAS scores was 48% (individual results ranging from 0% to 95%) and MCS efficacy was considered as good or satisfactory in 60% of the patients. Pain relief after 1 year tended to correlate with pain scores at 1 month postoperative, but not with age, pain duration or location, preoperative pain scores or sensory-motor status. Although the results of the crossover trial were slightly negative, which may have been due to carry-over effects from the operative and immediate postoperative phases, observations made during the open trial were in favour of a real efficacy of MCS in peripheral neuropathic pain. Analgesic effects were obtained on the sensory-discriminative rather than on the affective aspect of pain. These results suggest that the indication of MCS might be extended to various types of refractory, chronic peripheral pain beyond trigeminal neuropathic pain [5)].

2005

Ten patients underwent motor cortex stimulation between 1999 and 2002. Implantation was

performed via intraoperative neuronavigation and cortical mapping for stimulation site targeting. Nine patients had trigeminal neuropathic pain from postherpetic neuralgia, surgical injury, or unknown cause, and one patient had pain of central origin. Patients were evaluated with multimodality scales before, immediately after, and at designated intervals after surgery. Eight patients underwent permanent implantation after a trial evaluation. In two patients, the stimulating electrodes were removed after an unsuccessful trial. One of these patients had a lateral medullary infarct leading to central pain, and in another patient, there was no explanation for the pain.

The average duration of pain before surgery was 6 years. Postoperatively, there was an 88% rate of immediate pain relief (>50% on VAS) and a 75% rate of pain relief at mean follow-up of 10 months (range, 3-24 mo). Mean preoperative McGill Pain Questionnaire total pain rating index was 57 (higher than that observed in causalgia) for patients who did not undergo implantation and 53 for those who underwent implantation. Mean McGill Pain Questionnaire pain rating index at mean follow-up of 10 months was 24 (55% decrease). Mean VAS preoperatively was 9 in patients with stimulator implants and 8 in those whose stimulator was removed after the trial. Immediate postoperative mean VAS score was 1. This score stabilized 3 months after surgery. Patients with implanted stimulators reduced their pain medication dose by a mean of more than 50%. Three patients with facial weakness and sensory loss regained both strength and discriminative sensation during stimulation. In another patient, dysarthria improved. In a review of the literature, 29 (76%) of 38 patients with neuropathic facial pain treated with motor cortex stimulation achieved greater than 50% pain relief.

These results provide further support for the use of motor cortex stimulation in facial neuropathic pain and document pain improvement as measured by multidimensional scales. Observations of motor and sensory improvements during stimulation suggest that stimulation alters cortical plasticity and inhibits thalamic hyperactivity [6].

1)
Parravano DC, Ciampi DA, Fonoff ET, Monaco B, Navarro J, Yeng LT, Teixeira MJ, Hamani C. Quality of Life After Motor Cortex Stimulation: Clinical Results and Systematic Review of the Literature. Neurosurgery. 2018 Mar 14. doi: 10.1093/neuros/nyy060. [Epub ahead of print] PubMed PMID: 29547990.
2)
Rasche D, Tronnier VM. Clinical Significance of Invasive Motor Cortex Stimulation for Trigeminal Facial Neuropathic Pain Syndromes. Neurosurgery. 2016 Nov;79(5):655-666. PubMed PMID: 27465843.
3)
Isagulyan ED, Tomsky AA, Dekopov AV, Salova EM, Troshina EM, Dorokhov EV, Shabalov VA. [Results of motor cortex stimulation in the treatment of chronic pain syndromes]. Zh Vopr Neirokhir Im N N Burdenko. 2015;79(6):46-59; discussion 59-60. Russian. PubMed PMID: 26977794.
4)
Buchanan RJ, Darrow D, Monsivais D, Nadasdy Z, Gjini K. Motor cortex stimulation for neuropathic pain syndromes: a case series experience. Neuroreport. 2014 Jun 18;25(9):715-7. doi: 10.1097/WNR.0000000000000174. PubMed PMID: 24780896.
5)
Lefaucheur JP, Drouot X, Cunin P, Bruckert R, Lepetit H, Créange A, Wolkenstein P, Maison P, Keravel Y, Nguyen JP. Motor cortex stimulation for the treatment of refractory peripheral neuropathic pain. Brain. 2009 Jun;132(Pt 6):1463-71. doi: 10.1093/brain/awp035. PubMed PMID: 19336459.
6)
Brown JA, Pilitsis JG. Motor cortex stimulation for central and neuropathic facial pain: a prospective study of 10 patients and observations of enhanced sensory and motor function during stimulation. Neurosurgery. 2005 Feb;56(2):290-7; discussion 290-7. PubMed PMID: 15670377.