Original Article

A retrospective comparative cohort study of the effects of neural mobilization (NM) alone and NM combined with transcranial direct current stimulation in patients with cervical radiculopathy

Zhaoming Chen, Wenjie Zhang, Yanmei Yu, Tongcai Tan

Center for Rehabilitation Medicine, Rehabilitation & Sports Medicine Research Institute of Zhejiang Province, Department of Rehabilitation Medicine, Zhejiang Provincial People's Hospital (Affiliated People's Hospital, Hangzhou Medical College), Hangzhou, China

Contributions: (I) Conception and design: Z Chen; (II) Administrative support: Y Yu; (III) Provision of study materials or patients: W Zhang, Z Chen; (IV) Collection and assembly of data: Z Chen; (V) Data analysis and interpretation: Z Chen; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Tongcai Tan. Center for Rehabilitation Medicine, Rehabilitation & Sports Medicine Research Institute of Zhejiang Province, Department of Rehabilitation Medicine, Zhejiang Provincial People's Hospital (Affiliated People's Hospital, Hangzhou Medical College), Hangzhou 310014, China. Email: 29ttc@sina.com.

Background: Transcranial direct current stimulation (tDCS) and neural mobilization (NM) are widely used in clinical practice as two effective treatment. However, there have existed few studies of the combination of these two treatments, particularly in cervical radiculopathy (CR). To explore the value of combined tDCS and NM for the management of pain, disability, and quality of life (QoL) in patients with CR, authors designed this study.

Methods: According to certain inclusion criteria, 36 subjects were selected from 224 patients with CR enrolled in Zhejiang Provincial People's Hospital between June 2021 and December 2021. Subjects were divided into two groups based on the treatment they had already received at the hospital. Patients in the combined tDCS group received tDCS and NM therapy, while patients in the NM group received NM therapy alone. Visual analog scale (VAS), Neck Disability Index (NDI), and EuroQuol-5 dimensions (EQ-5D) scores were assessed at baseline, immediately after treatment, and at the 4-week follow-up to evaluate pain, neck disability, and the QoL of patients. SPSS 22.0 software (IBM Corp., Armonk, NY, USA) is used as main tool for data analysis.

Results: A total of 36 patients were enrolled (19 in the combined tDCS group and 17 in the NM group). The baseline VAS, NDI, and EQ-5D scores in the combined tDCS group were 54.3±16.4 mm, 35.1±14.7, and 0.62±0.15, respectively, while the baseline VAS, NDI, and EQ-5D scores in the NM group were 54.0±16.5 mm, 31.8±12.8, and 0.64±0.15, respectively. There was no significant difference in baseline data between the two groups. At the 4-week post-treatment follow-up, the VAS score was significantly lower in the combined tDCS group than in the NM group (24.5±16.1 and 40.7±17.3 mm, respectively, P=0.008), and the NDI was also significantly lower in the combined tDCS group than in the NM group (16.1±11.5 *vs.* 26.6±17.7, P=0.045). There was no significant difference between the combined tDCS and NM groups in EQ-5D (0.75±0.15 *vs.* 0.69±0.09, P=0.192).

Conclusions: Compared with NM therapy alone, combined tDCS and NM therapy may play a role in pain relief and neck disability improvement in CR patients.

Keywords: Cervical radiculopathy (CR); transcranial direct current stimulation (tDCS); neural mobilization (NM); neuromodulation; retrospective observational study

Submitted Jun 08, 2022. Accepted for publication Jul 26, 2022.
doi: 10.21037/apm-22-746
View this article at: https://dx.doi.org/10.21037/apm-22-746

Introduction

Cervical radiculopathy (CR) is a condition involving nerve root dysfunction in the cervical spine, usually manifested as pain radiating from the neck to the affected nerve root (1), which causes pain, disability, reduced range of motion, and poor quality of life (QoL) (2-4). The rate of surgery for CR and degenerative lesions has been rapidly increasing in recent years, but the surgery is costly and carries the risk of complications, making it important to determine the most effective nonsurgical management strategies (5).

One manipulative technique that has the potential for managing patients with cervical spondylolisthesis is neural mobilization (NM). The NM technique includes both slider and tensor maneuvers (6) which affect axoplasmic flow (7), movement of nerves and their connective tissue (8), and neural circulation by altering pressure and dispersing intraneural edema (9) in the nervous system. It also reduces the excitability of dorsal horn cells (10). In addition, transcranial direct current stimulation (tDCS) is a brain stimulation method that involves the use of at least two electrodes to pass a weak current (1–2 mA) through the cortex, which has recently been intensively evaluated as a tool for modulating symptoms of psychiatric and neurological disorders (11). A research study showed tDCS is able to regulating the neuronal activity of primary motor cortex and other brain areas associated with pain, alleviating the duration and intensity of pain (12). Furthermore, combining tDCS with other techniques is advocated by study to achieve more obvious improvement than either of the treatments alone (12). For instance, larger effects was acquired by Mendonca *et al.* on pain relief, depression, QoL and anxiety through a multidisciplinary treatment for fibromyalgia (13). Compared to other neuromodulation methods, tDCS has considerable therapeutic potential due to its relatively lower cost, portability, safety, and ease of use (14).

According to recent studies on the treatment of cervical spondylosis, tDCS and NM have been recommended for their antinociceptive and analgesic effects (15-17). The NM technique is applied to adjust the structure and function of the central nerve root to treat pain, limited range of motion, and disability caused by cervical spondylosis (18). A study has shown that tDCS modulates neuronal activity in the primary motor cortex and other brain regions associated with pain, relieving the duration and intensity of pain (18). In addition, another study has shown that tDCS, when used in conjunction with other techniques, achieves more significant improvements than any one of the treatments alone (12). For example, Mendonca *et al.* achieved greater results in pain relief, depression, QoL, and anxiety through multidisciplinary treatment of fibromyalgia (13). However, studies on the use of tDCS in patients with spinal neuropathy are still relatively few. In addition, there have been few studies on combining tDCS with NM in the treatment of patients with cervical neuropathy.

Therefore, the present study aimed to explore the impact of tDCS combined with NM on pain, disability and QoL in patients with CR. We present the following article in accordance with the STROBE reporting checklist (available at https://apm.amegroups.com/article/view/10.21037/apm-22-746/rc).

Methods

Study design and population

This retrospective observational study included patients with CR who were treated at the musculoskeletal pain clinic of the Department of Rehabilitation, Zhejiang Provincial People's Hospital between June 2021 and December 2021. The inclusion criteria were as follows: (I) patients aged 18–65 years; (II) patients diagnosed with CR for more than 3 months according to the clinical prediction rule (CPR) developed by Wainner *et al.* (19); and (III) patients who received NM therapy alone or received NM following tDCS. The exclusion criteria were as follows: (I) visual analog scale (VAS) (20) <20 mm; (II) patients who had undergone spinal surgery within 6 months; (III) cognitive impairment [Simplified Chinese Mini-Mental State Examination (MMSE) <20] (21); and (IV) common contraindications to tDCS, including major neurological disease, history of epilepsy, psychiatric disorders, liver and kidney disease, severe cardiopulmonary problems, intracranially implanted devices, and pregnancy. Patients who received tDCS followed by NM were defined as the combined tDCS group, while those who received simple NM were defined as the NM group.

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethics Committee of Zhejiang Provincial People's Hospital (No. QT2022259). Individual consent for this retrospective analysis was waived.

Data collection and definition

Our study is based on a comparative study of patients'

Table 1 Baseline comparison of demographic and clinical characteristics

Characteristics	Combined tDCS group (n=19), mean ± SD	NM group (n=17), mean ± SD	P value
Age (years)	52.4±7.5	52.4±8.0	0.98
Gender (male/female)	9/10	7/10	0.72
CR onset (years)	8.5±7.8	8.9±7.0	0.89
Pain frequency (continuous/intermittent/NE)	11/5/3	9/6/2	0.97
VAS baseline (mm)	54.3±16.4	54.0±16.5	0.96
NDI baseline	35.1±14.7	31.8±12.8	0.49
EQ-5D baseline	0.62±0.15	0.64±0.15	0.64

CR, cervical radiculopathy; NE, not evaluated; VAS, visual analog scale; NDI, Neck Disability Index; EQ-5D, EuroQuol-5 dimensions; tDCS, transcranial direct current stimulation; SD, standard deviation; NM, neural mobilization.

treatment. Clinical evaluation method: (I) demographic information (including age and gender) and clinical characteristics (including time of CR onset and pain frequency) were collected for each patient in this study; (II) the VAS (0–100 mm) scores were collected to assess the pain intensity of patients. Patients were classified as responders if their VAS score reduced by more than 30% compared to baseline at the 4-week follow-up; (III) a simplified Chinese version of the Neck Disability Index (NDI) (22), a 10-item questionnaire scoring 0 to 50, was used to assess the degree of neck disability, with higher NDI scores indicating more severe functional disability associated with cervical spondylosis; and (IV) the EuroQuol-5 dimensions (EQ-5D) (23) is a widely disseminated and validated Chinese version of the questionnaire used to assess patients' health-related QOL.

The clinical research design: the VAS, NDI, and EQ-5D scores were assessed in all patients before tDCS, immediately after treatment, and at the 4-week follow-up. For the combined tDCS group, patients received 20 minutes of tDCS stimulation, followed by NM treatment for 5 consecutive days. For the NM group, patients received NM treatment only. The NM treatment was performed by an experienced manual therapist in a rhythmic and fluid manner for 10 minutes according to the protocol reported by Elvey (24). A list of adverse tDCS reactions was collected from cases in the combined tDCS group after each stimulation (25), including neck pain, transient headache, mild tingling, pruritus, scalp burn, and skin redness.

Outcomes

The outcomes of this study included VAS, NDI, and EQ-5D scores at the 4-week follow-up and VAS, NDI, and EQ-5D immediately after treatment and adverse effects (AEs) of tDCS.

Statistical analysis

Data analysis was performed using SPSS 22.0 software (IBM Corp., Armonk, NY, USA). Normally distributed continuous variables were expressed as mean ± standard deviation (SD), skewed distributed continuous variables were expressed as median (range), and categorical variables were expressed as n (%). Comparisons between the two groups were performed using the Student's *t*-test for normally distributed continuous variables. Moreover, main effects for treatment and time were detected with the repeated-measures analysis of variance (RM-ANOVA) (between group factor: treatment; within-group factor: time). The Wilcoxon rank-sum test for skewed distributed continuous variables, and the chi-square test or Fisher's exact test for categorical variables. It was considered statistically significant when a two-sided $P<0.05$.

Results

A total of 224 patients with CR were screened, and 36 patients aged 52±47.7 years were finally included in the study. Some 19 patients (9 males) received combined tDCS therapy, and 17 patients (7 males) received NM therapy alone (*Table 1*). The mean time from CR onset was 8.7±7.4 years. A total of 20 cases had persistent cervical pain, while 11 cases experienced intermittent cervical pain. The baseline VAS, NDI, and EQ-5D scores in the combined tDCS group were 54.3±16.4 mm, 35.1±14.7, and 0.62±0.15, respectively, while

Table 2 Outcomes after treatment

Outcomes	Combined tDCS group (n=19), mean ± SD	NM group (n=17), mean ± SD	P value
VAS score (mm)			
After treatment	26.3±14.5	35.9±22.3	0.140
4-week follow-up	24.5±16.1	40.7±17.3	0.008
NDI score			
After treatment	17.5±13.7	22.6±18.3	0.365
4-week follow-up	16.1±11.5	26.6±17.7	0.045
EQ-5D score			
After treatment	0.78±0.13	0.72±0.18	0.225
4-week follow-up	0.75±0.15	0.69±0.09	0.192

VAS, visual analog scale; NDI, Neck Disability Index; EQ-5D, EuroQuol-5 dimensions; tDCS, transcranial direct current stimulation; SD, standard deviation; NM, neural mobilization.

Table 3 AEs reported after tDCS simulation

AE	Cases (%)
Skin redness	11 (57.9)
Tingling	7 (36.8)
Headache	4 (21.1)
Sleepiness	4 (21.1)
Trouble to concentrate	3 (15.8)
Dizziness	1 (5.3)

AE, adverse effect; tDCS, transcranial direct current stimulation.

the baseline VAS, NDI, and EQ-5D scores in the NM group were 54.0±16.5 mm, 31.8±12.8, and 0.64±0.15, respectively. There were no differences in age, gender, time from CR onset, pain frequency, VAS, NDI, or EQ-5D score between the two groups.

In both groups, the VAS and NDI scores were significantly lower after treatment than before treatment, and the EQ-5D score was significantly higher after treatment (all P<0.001). There were no significant differences in VAS, NDI, and EQ-5D between the two groups immediately after treatment (*Table 2*). At the 4-week post-treatment follow-up, the VAS score was significantly lower in the combined tDCS group than in the NM group (24.5±16.1 and 40.7±17.3 mm, respectively, P=0.008) (*Table 2*). RM-ANOVA analysis was performed on VAS and showing a significant effect of time-treatment interaction: F=8.9; P<0.001. The percentage of responders was significantly higher in the combined tDCS group than in the NM group (94.73% *vs.* 41.18%, P<0.001). At the 4-week post-treatment follow-up, the NDI score was also significantly lower in the combined tDCS group than in the NM group (16.1±11.5 *vs.* 26.6±17.7, P=0.045) (*Table 2*). RM-ANOVA analysis was performed on NDI and showing a significant effect of time-treatment interaction: F=8.2 and P<0.001. There was no significant difference between the combined tDCS and NM groups in EQ-5D score (0.75±0.15 *vs.* 0.69±0.09, P=0.192).

The most frequent AE after tDCS was skin redness, with 11 (57.89%) cases of skin redness reported (*Table 3*). Tingling was reported by 7 (36.8%) patients, while headache and sleepiness was reported by 4 (21.1%) patients in the combined tDCS group (*Table 3*). Three (15.8%) cases of impaired concentration and 1 (5.3%) case of dizziness were reported after tDCS treatment (*Table 3*). All the reported AEs were mild and temporary.

Discussion

The present study showed that after combined tDCS and NM therapy, patients had lower VAS and NDI scores 4 weeks after treatment than those who received NM alone, indicating that tDCS combined with NM may result in better long-term pain relief and improved disability in CR patients compared to NM treatment alone. This study might provide a clinical basis for exploring non-invasive treatment options for patients with CR.

The efficacy of tDCS therapy for neuropathic pain has been reported in different ways and its efficacy is

inconclusive. For example, Attal *et al.* compared the effects of tDCS with repetitive transcranial magnetic stimulation (rTMS) on neuropathic pain induced by radiculopathy in a randomized sham-controlled comparative study, which showed a lack of analgesic effect of tDCS. However, rTMS had a significant analgesic effect on neuropathic pain induced by radiculopathy (26). In contrast, Mori *et al.* treated chronic neuropathic pain in patients with multiple sclerosis with tDCS for 5 days and reported positive results in pain control and retained a longer period of remission, which is partially similar to the results in this study (27). A meta-analysis targeting neuropathic pain after spinal cord injury showed that tDCS has a positive effect on specific chronic pain. The reason for these different findings may be that in the study by Attal *et al.* (26), the authors chose either a single tDCS or rTMS to treat patients with neuropathic pain; however, this study compared the combined tDCS and NM therapy with NM therapy alone. Thus, tDCS may be more appropriate for use as an adjunctive therapy in combination with other therapies to enhance its effectiveness, which to some extent confirms previous studies on combination therapies including tDCS (28,29). Furthermore, in the present study, tDCS combined with NM effectively alleviated the sequelae of CR, and the long-term effects in follow-up are consistent with previous studies of tDCS for neuropathic pain (27,30,31).

When using combination therapies, the order of the combinations between the different therapies may impact the efficacy. A study by Cabral *et al.* showed that the administration of tDCS before the intervention optimized its effect, and data from other studies suggest that the application of tDCS before or during the intervention can achieve a lasting modulatory effect (32-34). In this study, tDCS directly stimulated central neural targets, and its modulatory effect on neuronal excitability facilitated central sensitization and enhanced the efficacy of subsequent NM. This mechanism is essential to produce analgesic and antinociceptive effects to facilitate combination therapy.

The limitations of this study were as follows: (I) the parameters of tDCS may still have been imperfect to maximize its effect after treatment; (II) there is no valid Chinese version of a clinical tool to assess the central sensitization mechanism in patients with cervical spondylosis, so it was not addressed in this study; (III) based on the biopsychosocial model, the effect of emotion regulation on pain is an important aspect of tDCS (35), which was not explored in this study; (IV) this study had a retrospective design and a small sample size, with potential underpowering of some analyses. The AEs after tDCS stimulation were retrospectively collected in the combined tDCS group, but no AE data were available in the NM group; (V) the limitaions of this comparative study is that sample grouping can be subjective and has selection bias. The results may be influenced because of that.

The present study demonstrated that the pain relief provided by tDCS was maintained beyond the duration of tDCS stimulation at the 4-week follow-up. Despite its mild AEs such as skin redness, the combined tDCS and NM therapy might result in clinically meaningful and superior results to the NM therapy alone. This study suggests that the combination of tDCS and NM can lead to long-term beneficial clinical improvement in patients with CR.

Acknowledgments

Funding: None.

Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://apm.amegroups.com/article/view/10.21037/apm-22-746/rc

Data Sharing Statement: Available at https://apm.amegroups.com/article/view/10.21037/apm-22-746/dss

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://apm.amegroups.com/article/view/10.21037/apm-22-746/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethics Committee of Zhejiang Provincial People's Hospital (No. QT2022259). Individual consent for this retrospective analysis was waived.

References

1. Rhee JM, Yoon T, Riew KD. Cervical radiculopathy. J Am Acad Orthop Surg 2007;15:486-94.
2. Eubanks JD. Cervical radiculopathy: nonoperative management of neck pain and radicular symptoms. Am Fam Physician 2010;81:33-40.
3. Kuijper B, Tans JT, Schimsheimer RJ, et al. Degenerative cervical radiculopathy: diagnosis and conservative treatment. A review. Eur J Neurol 2009;16:15-20.
4. Rubinstein SM, Pool JJ, van Tulder MW, et al. A systematic review of the diagnostic accuracy of provocative tests of the neck for diagnosing cervical radiculopathy. Eur Spine J 2007;16:307-19.
5. Zhang YH, Hu HY, Xiong YC, et al. Exercise for Neuropathic Pain: A Systematic Review and Expert Consensus. Front Med (Lausanne) 2021;8:756940.
6. Saragiotto BT, Maher CG, Yamato TP, et al. Motor control exercise for chronic non-specific low-back pain. Cochrane Database Syst Rev 2016;(1):CD012004.
7. Naish KR, Houston-Price C, Bremner AJ, et al. Effects of action observation on corticospinal excitability: Muscle specificity, direction, and timing of the mirror response. Neuropsychologia 2014;64:331-48.
8. Coppieters MW, Alshami AM. Longitudinal excursion and strain in the median nerve during novel nerve gliding exercises for carpal tunnel syndrome. J Orthop Res 2007;25:972-80.
9. Schmid AB, Elliott JM, Strudwick MW, et al. Effect of splinting and exercise on intraneural edema of the median nerve in carpal tunnel syndrome--an MRI study to reveal therapeutic mechanisms. J Orthop Res 2012;30:1343-50.
10. Bialosky JE, Bishop MD, Price DD, et al. A randomized sham-controlled trial of a neurodynamic technique in the treatment of carpal tunnel syndrome. J Orthop Sports Phys Ther 2009;39:709-23.
11. Lefaucheur JP, Antal A, Ayache SS, et al. Evidence-based guidelines on the therapeutic use of transcranial direct current stimulation (tDCS). Clin Neurophysiol 2017;128:56-92.
12. Pinto CB, Teixeira Costa B, Duarte D, et al. Transcranial Direct Current Stimulation as a Therapeutic Tool for Chronic Pain. J ECT 2018;34:e36-50.
13. Mendonca ME, Simis M, Grecco LC, et al. Transcranial Direct Current Stimulation Combined with Aerobic Exercise to Optimize Analgesic Responses in Fibromyalgia: A Randomized Placebo-Controlled Clinical Trial. Front Hum Neurosci 2016;10:68.
14. Mutz J, Edgcumbe DR, Brunoni AR, et al. Efficacy and acceptability of non-invasive brain stimulation for the treatment of adult unipolar and bipolar depression: A systematic review and meta-analysis of randomised sham-controlled trials. Neurosci Biobehav Rev 2018;92:291-303.
15. Nekhendzy V, Lemmens HJ, Tingle M, et al. The analgesic and antihyperalgesic effects of transcranial electrostimulation with combined direct and alternating current in healthy volunteers. Anesth Analg 2010;111:1301-7.
16. David MCMM, Moraes AA, Costa MLD, et al. Transcranial direct current stimulation in the modulation of neuropathic pain: a systematic review. Neurol Res 2018;40:555-63.
17. Blanpied PR, Gross AR, Elliott JM, et al. Neck Pain: Revision 2017. J Orthop Sports Phys Ther 2017;47:A1-A83.
18. Coppieters MW, Butler DS. Do 'sliders' slide and 'tensioners' tension? An analysis of neurodynamic techniques and considerations regarding their application. Man Ther 2008;13:213-21.
19. Wainner RS, Fritz JM, Irrgang JJ, et al. Reliability and diagnostic accuracy of the clinical examination and patient self-report measures for cervical radiculopathy. Spine (Phila Pa 1976) 2003;28:52-62.
20. Shafshak TS, Elnemr R. The Visual Analogue Scale Versus Numerical Rating Scale in Measuring Pain Severity and Predicting Disability in Low Back Pain. J Clin Rheumatol 2021;27:282-5.
21. Grigoletto F, Zappalà G, Anderson DW, et al. Norms for the Mini-Mental State Examination in a healthy population. Neurology 1999;53:315-20.
22. Wu S, Ma C, Mai M, et al. Translation and validation study of Chinese versions of the neck disability index and the neck pain and disability scale. Spine (Phila Pa 1976) 2010;35:1575-9.
23. Luo N, Li M, Liu GG, et al. Developing the Chinese version of the new 5-level EQ-5D descriptive system: the response scaling approach. Qual Life Res 2013;22:885-90.
24. Elvey RL. Treatment of arm pain associated with abnormal brachial plexus tension. Aust J Physiother 1986;32:225-30.
25. Nikolin S, Huggins C, Martin D, et al. Safety of repeated sessions of transcranial direct current stimulation: A systematic review. Brain Stimul 2018;11:278-88.

26. Attal N, Ayache SS, Ciampi De Andrade D, et al. Repetitive transcranial magnetic stimulation and transcranial direct-current stimulation in neuropathic pain due to radiculopathy: a randomized sham-controlled comparative study. Pain 2016;157:1224-31.
27. Mori F, Codecà C, Kusayanagi H, et al. Effects of anodal transcranial direct current stimulation on chronic neuropathic pain in patients with multiple sclerosis. J Pain 2010;11:436-42.
28. Rumi DO, Gattaz WF, Rigonatti SP, et al. Transcranial magnetic stimulation accelerates the antidepressant effect of amitriptyline in severe depression: a double-blind placebo-controlled study. Biol Psychiatry 2005;57:162-6.
29. Brunoni AR, Valiengo L, Baccaro A, et al. The sertraline vs. electrical current therapy for treating depression clinical study: results from a factorial, randomized, controlled trial. JAMA Psychiatry 2013;70:383-91.
30. Thibaut A, Carvalho S, Morse LR, et al. Delayed pain decrease following M1 tDCS in spinal cord injury: A randomized controlled clinical trial. Neurosci Lett 2017;658:19-26.
31. Straudi S, Buja S, Baroni A, et al. The effects of transcranial direct current stimulation (tDCS) combined with group exercise treatment in subjects with chronic low back pain: a pilot randomized control trial. Clin Rehabil 2018;32:1348-56.
32. Cabral ME, Baltar A, Borba R, et al. Transcranial direct current stimulation: before, during, or after motor training? Neuroreport 2015;26:618-22.
33. Dasilva AF, Mendonca ME, Zaghi S, et al. tDCS-induced analgesia and electrical fields in pain-related neural networks in chronic migraine. Headache 2012;52:1283-95.
34. Villamar MF, Wivatvongvana P, Patumanond J, et al. Focal modulation of the primary motor cortex in fibromyalgia using 4×1-ring high-definition transcranial direct current stimulation (HD-tDCS): immediate and delayed analgesic effects of cathodal and anodal stimulation. J Pain 2013;14:371-83.
35. Melzack R. Pain and the neuromatrix in the brain. J Dent Educ 2001;65:1378-82.

(English Language Editor: J. Jones)

Cite this article as: Chen Z, Zhang W, Yu Y, Tan T. A retrospective comparative cohort study of the effects of neural mobilization (NM) alone and NM combined with transcranial direct current stimulation in patients with cervical radiculopathy. Ann Palliat Med 2022;11(9):2961-2967. doi: 10.21037/apm-22-746

