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Comparative analysis of surgical techniques used to repair a closed sciatic nerve injury in patients undergoing total hip replacement

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Abstract

Introduction A variety of surgical techniques used to treat a closed sciatic nerve injury after total hip replacement (THR) require careful evaluation and comparison of short- and long-term outcomes of the complex management emphasizing a paucity of publications on the subject and a high social and economic role of the issue. **The aim of the study** was to compare outcomes of various surgical techniques used to treat closed sciatic nerve injuries after THR. **Material and methods** A total of 94 patients with closed sciatic nerves injuries associated with THR were divided into three groups. Microsurgical neurolysis of the sciatic nerve was produced for patients of Group I; patients of group II underwent microsurgical neurolysis of the sciatic nerve and electrical nerve stimulation; patients of group III had microsurgical neurolysis and electrical stimulation of the sciatic nerve with multichannel electrodes and segmental apparatus of the spinal cord at the conus and epiconus level. Clinical and neurological tests, dynamic electrophysiological monitoring were employed for clinical and functional evaluation. **Results** In In the postoperative period, positive dynamics in clinical and electrophysiological parameters with improved pain, lower limb functionality, increased amplitudes and decreased latency of M-response with most positive changes observed in Group III compared to Group I and Group II ($p < 0.05$). **Discussion** The function of the sciatic nerve restored in all patients with the most pronounced effect recorded in group III. The effect from the technique was associated with a simultaneous electrical stimulation of the trunk of the peripheral nerve and the segmental apparatus of the spinal cord causing synergetic effect on the structures. **Conclusion** The most effective method of surgical treatment was the use of Microsurgical neurolysis combined with two-level electrical stimulation was shown to be most effective and characterized by faster pain regression and positive dynamics in clinical and electrophysiological parameters in the affected lower limb of patients Group III.

Keywords: sciatic nerve, trauma, total hip replacement, electric stimulation, surgical management

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INTRODUCTION

A closed sciatic nerve injury (CSNI) following a total hip replacement (THR) is a challenging and devastating complication with the incidence between 0.17 and 8 % [1-3]. The condition can be transient in 50-70 % of cases and not accompanied by presenting signs [4, 5]. The increasing volume of THRs leads to greater prevalence of CSNI among patients of working age [6]. Risk factors are limb lengthening during surgery, female gender, re-operations, bone cement utilization, posterior approach to the hip joint correlate with a greater complication rate [7-10]. Sciatic nerve neuropathy (SN) following THR can cause pain, impaired contractile function of lower-limb muscles, atrophy and joint contractures negatively affecting treatment outcomes [11, 12].

Surgical management treatment of CSNI can be challenging due to the high level of damage to the nerve trunk at the level of the infrapiriform and greater sciatic foramen during THR, which can require a highly traumatic approach associated with massive dissection of soft tissue structures and lead to hip adhesions at the surgical site increasing the number of poor treatment results [13, 14]. Microsurgical neurolysis (MN) is performed as a standard treatment for the condition, and various methods of direct electrical stimulation (ES) of the SN can be offered [13, 15, 16]. However, the use of the techniques does not always provide recovery of lower-limb function and is accompanied by frequent recurrence of complex regional pain syndrome (CRPS) in the lower limb [17-19]. Combined stimulation of the peripheral nerve and the segmental apparatus of the spinal cord can be employed and improve outcomes at a short and long term [20]. With a variety of ES techniques, there is no consensus in the literature regarding indications, timing and regimens used, and most studies investigating its effect on the regenerative processes occurring in the myoneural complex were performed on experimental models [21-25]. The high incidence of CSNI following THR and the frequency of poor results determine the relevance of this study, aimed at search of the most effective method of surgical treatment. The objective of the study was to compare outcomes of various surgical techniques used to treat closed sciatic nerve injuries after THR.

MATERIAL AND METHODS

The study was longitudinal, open-label, prospective with a historical control group. Inclusion criteria were included working age, isolated nature of the SN injury after THR (grade 3 idiopathic coxarthrosis, body mass index from 18.5 to 24.99, use the anterolateral approach to the hip joint and cementless fixation of THR), Sunderland grades II, III, IV injury to the nerve trunks [26], CRPS in the affected limb, conservative treatment failed after 3 months of injury, voluntary informed consent signed by the patient participating in the study. The study included 94 patients with CSNI who were treated at the Research Institute of Trauma, Orthopaedics and Neurosurgery of Saratov State Medical University between 2005 and 2022. There were 41 (43.6 %) male and 53 (56.4 %) female patients. There were no gender differences between the study groups ($p = 0.785$). The study was conducted in three groups being homogeneous in severity of nerve damage. Microsurgical neurolysis of the sciatic nerve was produced for patients of Group I ($n = 29$); patients of group II ($n = 32$) underwent microsurgical neurolysis of the sciatic nerve and single-level electrical nerve stimulation; patients of group III ($n = 33$) had MN performed in combination with two-level ES (stimulating electrodes placed to the trunk of the SN and to the segmental apparatus of the SC). Outcome measures included visual analogue scale (VAS) [27], five-point muscle strength rating scale [28], five-point sensitivity rating scale [29], the Oswestry Disability Index (ODI) [30]. Dynamic electroneuromyography (ENMG) of the lower extremities was used as an objective research method. Statistical analysis of the results was performed using Statistica 13.0, Microsoft Office Excel 2019. The data did not follow the normal distribution and non-parametric statistical methods were used to calculate the median and interquartile range (Me (Q1; Q3)), the Wilcoxon test for related samples, the Kruskal-Wallis test. Differences between groups were considered statistically significant at $p < 0.05$.

RESULTS

Pain intensity was high in all patients ($n = 94$) and scored 7.0 (6.0; 8.0) points, motor impairment in the affected limb scored 1.0 (0; 2), sensitive disorders scored 1.0 (0; 2) and the groups were homogeneous with the parameters (Kruskal – Wallis test pVAS = 0.949, pmotor = 0.452, psens = 0.950). Functional deficiency measured preoperatively with the ODI scored 31.0 (25.0; 40.0) in group I, 27.0 (21.0; 36.0) in group II, and 29.5 (21.5; 41.0) in group III with no differences in the homogeneity of the three groups ($p = 0.579$). Preoperative ENMG indicated severe damage to the SN, with injury to both portions, as shown in Table 1.

As seen from Table 1, ENMG measurements of all patients ($n = 94$) showed a decreased amplitude and an increased latent period of the M-response, which indicated a severe axonal demyelinating damage to the SN. The patients demonstrated a decrease in the severity of pain with complete regression observed in patients of group III ($p < 0.05$) only (Fig. 1) at a six-month follow-up.

The dynamics in sensitivity and muscle strength in the groups were weakly expressed, and no statistically significant differences in the above parameters were detected throughout the observation period ($p > 0.05$). The postoperative dynamics in ODI score was less pronounced in patients of group I and group II compared to those in group III due to decreased severity of pain and led to an improvement in self-care routine. ODI scored 28.0 (20.0; 34.0) in group I, 16.5 (9.0; 21.5) in group II, 5.9 (4.3; 8.5) in group III, $p < 0.05$.

ENMG measurements indicated positive clinical and neurological dynamics in the parameters with restored peroneal and tibial nerve conduction through increased amplitude of the M-response and decreased latency. This indicated the improvement in sensory-motor regeneration of peripheral nerves of the lower limb. The median amplitudes of the M-response at the distal point of the stimulated peroneal nerve measured 1.2 (0.3; 2.6) in group I, 1.6 (1.2; 2.2) in group II, 1.7 (0.7; 2.4) in group III, ($p < 0.05$) (Fig. 2).

Table 1

Preoperative electroneuromyography parameters of the lower limb measured in patients with closed sciatic nerve injury following total hip arthroplasty

Nerve	Parameter	Group 1 Me (Q1; Q3)	Group 2 Me (Q1; Q3)	Group 3 Me (Q1; Q3)
Peroneal	M-response (mA)	0.7 (0.1; 1.5)	0.7 (0.0; 1.3)	1.0 (0.4; 1.3)
	LP (ms)	3.3 (3.1; 4.4)	3.3 (0.0; 4.4)	4.8 (4.2; 5.1)
Tibial	M-response (mA)	2.0 (1.0; 4.6)	1.3 (1.0; 2.2)	1.1 (0.6; 1.6)
	LP (ms)	4.3 (3.5; 5.5)	5.6 (4.6; 6.7)	5.3 (4.6; 6.5)

Note: Me, median (25^{th} and 75^{th} percentiles), $p > 0.05$.

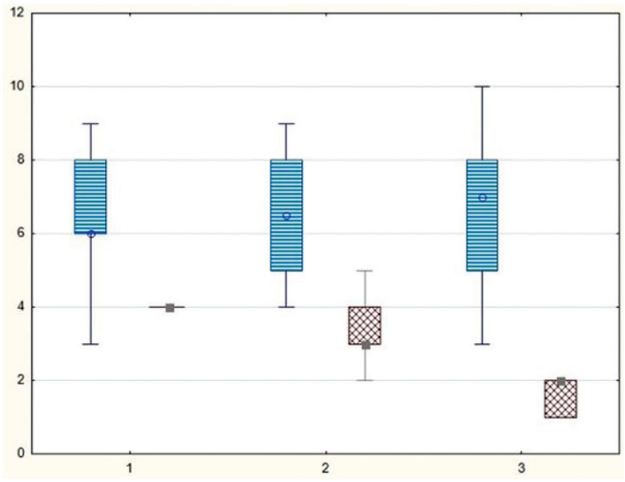

Fig. 1 Dynamics in pain intensity

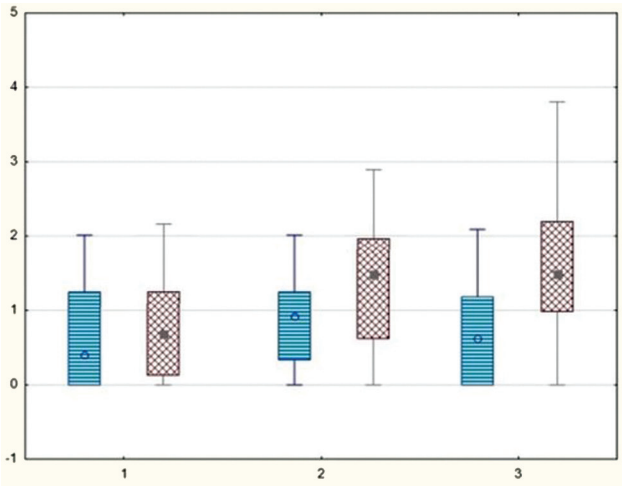

Fig. 2 Dynamics in M-response of the peroneal nerve

The amplitude of the M-response of the tibial nerve measured 2.1 (1.1; 2.9) in group I, 2.2 (1.4; 2.6) in group II, 3.2 (1.3; 5.60) in group III, ($p < 0.01$) postoperatively (Fig. 3).

Evident positive dynamics in clinical, neurological and electrophysiological parameters resulted in regression of pain, improved functionality of the lower limb, increased amplitude and decreased latency of the M-response registered in patients of group III, which indicated the advantage of combined MN and two-level ES in the treatment of patients with CSNI following THR.

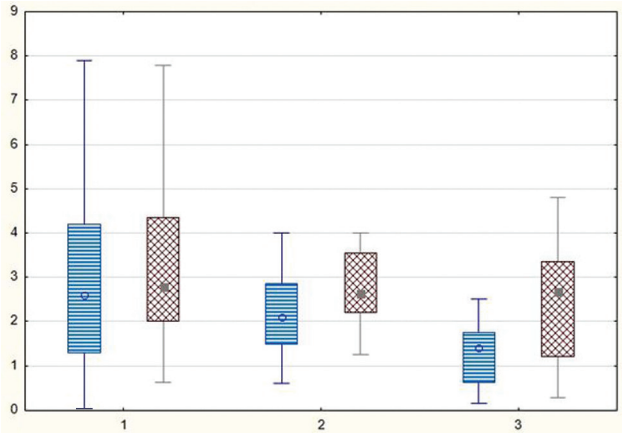

Fig. 3 Dynamics in M-response of the tibial nerve

DISCUSSION

The study was a continuation of work on exploring the results of treatment of patients with CSNI following THR [31]. The SN function recovered in all patients with the most evident effect seen in group III. Analysis of the literature data showed a small number of publications on the treatment of this pathology [32, 33], which complicated a significant comparison of the data obtained in the original study with data from Russian and foreign literature. The positive effect of the MN technique in combination with two-level ES was associated with the simultaneous electric-field pulses effect on the peripheral nerve trunk and the segmental apparatus of the spinal cord having had a mutually reinforcing effect on the peripheral nervous system. A similar technique was reported by I.A. Meshcheryagina. et al. in the complex treatment of patients with damage to peripheral nerves [20, 33] and the findings were in line with those of our series, despite some differences in placement of stimulating electrodes employed as minimally invasive technologies [34].

Clear criteria, indications and an optimal algorithm for a specific surgical treatment have not been identified for patients CSNI following THR. Although functional neurosurgery has undergone rapid growth over the last few years and clinical improvement being evident with different ES modalities the timing, duration and modes of electrical neuromodulation have not been fully elucidated [11, 35], which necessitates further research to determine the most effective method and establish a personalized approach to the treatment of patients with CSNI following THR.

CONCLUSION

A comparative analysis of different surgical treatments of patients with CSNI following THR demonstrated significant effectiveness of the SN technique in combination with ES of the SN trunks and the segmental apparatus of the spinal cord facilitating improved results of treatment with a faster pain relief in the affected lower limb and improved electrophysiological parameters.

Conflict of interest *The authors declared no potential conflicts of interest with respect to the authorship and/or publication of this article.*

Financing *The study was carried out as part of the research project of the Research Institute of Trauma, Orthopaedics and Neurosurgery of Saratov State Medical University SSMU "Development of a system for supporting medical decisions in the complex treatment of injuries of the peripheral nervous system using electrical neuromodulation methods", state registration number R&D 121032300173-9.*

Ethical expertise *The study was reviewed and approved by the local ethics committee of the Saratov State Medical University named after. IN AND. Razumovsky Ministry of Health of Russia (protocol No. 4, dated November 1, 2022).*

Written informed consent *for the participation in the research project was obtained from the patients.*

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Aitemirov Sh.M. – research, data processing.
Ostrovskii V.V. – control, project management.