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# Electrophysiological patterns of sciatic nerve in patients with arthrosis deformans of the hip

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***ABSTRACT***

***BACKGROUND:*** Neurological complications in sciatic nerve (SN) after a total hip replacement (THR) are observed in 0.9–3.2% of cases in patients with arthrosis deformans and age-related morphologic changes in SN. These cause the need for SN evaluation before THR. This research was aimed at the evaluation of the initial SN capacity with electrophysiological findings in patients with arthrosis deformans of the hip.

***MATERIALS AND METHODS:*** Electroneuromyography (ENMG) was used to evaluate fibular and tibial nerves M-responses as well as F-waves in 66 patients with dysplastic coxarthrosis and 12 patients with posttraumatic coxarthrosis. The findings were compared to those of the controls.

***RESULTS:*** Changes in ENMG findings for fibular nerve in 49 patients with dysplastic coxarthrosis were bilateral and showed significant difference only from the norm. In 19 of 66 cases (27.9%) low M-responses ($p$ <0.02) were found in the side subject to THR. In 87.3% of cases, the signs of a decrease in the conductivity of proximal segments of the tibial nerve were revealed. In patients with posttraumatic coxarthrosis, the significant decrease in ENMG findings from both fibular and tibial nerves was observed in the affected side, they made up just 42-50% of those in the opposite side. Asymptomatic progress of denervation damage in hip and tibia muscles sometimes required needle EMG to fund the signs of motor innervation disorder. A-waves revealed in 65% of patients suggested local damage to one or both portions of SN.

***CONCLUSION:*** ENMG findings in patients with dysplastic arthrosis of the hip enabled revealing of the signs of neuropathy before surgeries and decreasing the risk of neurologic post-surgery complications.

**Keywords:** sciatic nerve; arthrosis deformans; THR; hip joint; ENMG.

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## BACKGROUND

Total endoprosthesis (TEP) of the hip joint (HJ) is becoming steadily performed worldwide; in Russia, it is 60.2% of all TEPs [1]. Dysplastic coxarthrosis accounts for up to 80% of coxarthrosis cases [2–4]. One of the complications of total hip replacement (THR) is damage to the sciatic nerve (SN), which varies from 0.9% to 3.2%. In this regard, special attention is required for patients with a history of surgical treatment for congenital HJ pathology, since the frequency of neurological complications after joint implantation is three times higher than that in patients with dysplastic coxarthrosis [5–7]. Many THR surgeries are performed on patients aged >55 years, when age-related morphological restructuring occurs even without SN failure, with a decrease in the number of nerve fibers in its bundles by 36%, the amount of connective tissue increases by 17%, and the thickness of the myelin sheath decreases [8, 9]. An unfavorable factor that also affects the state of the SN in patients with dysplastic coxarthrosis is the presence of persistent radicular lesions and myodystrophic changes in the muscles surrounding the HJ during joint replacement [10–15]. If the SN is damaged, both parts can be affected, but the peroneal region is affected more often and more roughly. This can be due to the anatomical characteristics of the peroneal region of the nerve, options for dividing the SN into regions, and a weak vascular network that supplies blood to the nerve trunk [16].

By knowing the anatomical and morphological aspects of the SN in patients with severe osteoarthritis of the HJ, before TEP, it becomes necessary to examine objectively the condition of the SN to prevent postoperative neurological complications. Meanwhile, the results of electroneuromyography (ENMG) and electromyography (EMG), which assess the state of peripheral nerves in patients with deforming arthrosis (DA) of the HJ before TEP, are not sufficiently investigated [17, 18]. The possible reason is that most patients do not show clinical signs of peripheral nerve neuropathy during the initial examination.

*This study aimed* to assess the initial condition of the SN and its functional activity according to electrophysiological data in patients with DA of the HJ.

## MATERIALS AND METHODS

The study included 78 patients aged 36–70 (mean age, 57.5 ± 10.6) years, of which 61 were female and 17 were male. Of the 78 patients, 66 were diagnosed with stage 2–3 dysplastic coxarthrosis based on the results of clinical and radiation diagnostics and 12 patients were diagnosed with post-traumatic coxarthrosis. Of the 66 patients, nine had undergone surgery during childhood for congenital dislocation of the HJ. The control group consisted of 20 people without degenerative joint lesions and neurological complaints. The inclusion criteria were as follows: presence of stage 2–3 dysplastic coxarthrosis and post-traumatic DA of the HJ without clinical symptoms of SN neuropathy. The exclusion criterion was a history of revision total arthroplasty (reTEP).

Upon admission, all patients complained of pain of varying intensities in the area of the affected HJ, aggravated by movement and exertion, support inability of the limb, and shortening. Clinically, all patients showed relative shortening of the affected lower limb of varying severities, namely, up to 3 cm in 28 (37.3%) patients, 3 cm in 45 (60%), and over 4 cm in 5 (3%). The strength of the tibial muscles was assessed on the scale of muscle contraction strength and volume of voluntary movements and was graded 4–5 points. Weak parasthesias at the levels of the thigh and lower leg were recorded in 4 of 10 patients after fracture dislocation of the HJ and in 7 patients with dysplastic coxarthrosis. There were no restrictions on the dorsal and plantar flexion in the ankle joint.

ENMG and EMG were performed in all patients preoperatively on a Dantec Keypoint electromyograph (Alpine Biomed, Denmark) following standard research methods with the determination of motor responses (M-responses), speed of impulse conduction along the motor fibers (SICeff), and peroneal and tibial nerves from two sides. The conductivity of the proximal segments of the nerves and roots of the spinal cord was assessed by the latent period of late antidromic responses of motor neurons, i.e., LP of F-waves [19, 20].

ENMG data were compared on the sides and with the indices of the control group. Since patients with dysplastic coxarthrosis can have bilateral lesions, the affected side was the side on which the implantation of the joint endoprosthesis was planned.

Given the difference in the etiopathogenesis and frequency of neurological complications in primary and secondary (post-traumatic) DA of the HJ, the patients were distributed into two groups. Group 1 included patients with dysplastic coxarthrosis, and group 2 included patients with a history of traumatic injury to the HJ, without taking into account the degree of limb shortening.

*Ethics committee*. The study protocol was approved by the local ethics committee of the V.I. Razumovsky Saratov State Medical University of the Ministry of Health of Russia (No. 7 dated 02/02/2021).

The results were processed statistically using the StatSoft Statistica software package. Quantitative parameters in the study groups (prospective and retrospective) were compared using the Mann–Whitney test. The criterion for the significance of the differences was $p < 0.05$.

## RESULTS

ENMG was performed upon hospital admission. ENMG data of the peroneal and tibial nerves of the patients with dysplastic coxarthrosis are presented in Table 1.

In comparison, ENMG indices of the M-responses of the peroneal and tibial nerves and LP of the F-waves of group 1 on the sides did not show significant differences. Only the

**Table 1.** Indicators of electroneuromyography of the peroneal and tibial nerves in patients with dysplastic coxarthrosis

| Nerve ($n$ = 68), side | LP, ms | Amplitude, mV | Conduction block, % | SICeff, m/s | F-wave, ms, $n$ = 37 |
|---|---|---|---|---|---|
| Fibular, affected | 3,0±0,6 | 3,5±1,7*** | 33,6±13,3 | 49,6±7,5 | 39,5±11,3 |
| Relatively healthy | 2,8±0,6 | 4,14±1,4 | 23,2±12 | 50,2±11,5 | 42,1±5,3 |
| Control | 2,9±0,3 | 5,1±0,8 | 9,6±6,6 | 52,9±4,8 | 41,9±4,7 |
| Tibial, affected | 3,8±0,7* | 7,6±2,6 | 44,7±23,9** | 45,4±5,9 | 42,9±4,4 |
| Relatively healthy | 3,9±0,7 | 6,9±2,9 | 37,7±17,9 | 48,3±9,3 | 44,1±5,9 |
| Control | 2,9±0,5 | 9,4±1,3 | 9,0±6,7 | 55,8±4,2 | 45,6±3,8 |

*Note*. LT — latent time, SICeff — speed of impulse conduction along motor fibers. Significant differences between the same indicators of the affected side and the data of the control group.
*$p$ <0.02, **$p$ <0.03, ***$p$ <0.015.

control group data showed significant differences in the amplitude of the M-responses of the peroneal nerve. This can be due to a bilateral decrease in motor responses in 49 (72.1%) of 68 patients. In 19 (27.9%) patients, the indicators of the peroneal nerve on the affected side were below the lower limit of the norm and were significantly different from the contralateral side (1.7 ± 0.6; $p$ = 0.02) and the norm (0.00001). No significant differences in the ENMG data of the tibial nerve were noted. Results of the comparison of the M-responses of the tibial nerve recorded during stimulation at different levels provided more information. In 86.8% of the cases (59 patients), the amplitude of the proximal M-response relative to the values of the distal one decreased by more than 35%. On average, the value of the conduction block of the proximal nerve segment was 43.7% ± 23.9% ($p$ < 0.05), with a maximum value of 93%.

The mean values of the impulse conduction time at the level of the tibia and S1 roots of the spinal cord, according to the LP of F-waves, were not significantly different from the control group. In 23% of the patients with DA of the HJ, asymmetry of the tibial LP of the F-waves was observed, which exceeded the permissible values and averaged 3.5 ± 0.7 ms. ENMG signs of radicular lesions were confirmed by computed tomography and magnetic resonance imaging. Changes in neuronal responses recorded for the stimulation of the peroneal nerve were manifested by the absence of F-waves in patients with an M-response amplitude <3.0 mV.

Table 2 presents the results of the primary ENMG study of the peroneal and tibial nerves of 12 patients with post-traumatic arthrosis of the HJ. Several indicators in patients with secondary DA of the HJ were different. That is, a significant decrease was found at the time of impulse conduction at the level of nerve terminals ($p$ < 0.002), amplitudes of M-responses ($p$ < 0.002), SICeff ($p$ < 0.04), and indices of the LP of the F-waves ($p$ < 0.03) in the affected side relative to the contralateral limb. ENMG indicators of the motor responses of the tibial and peroneal nerves of the affected limb were only 42.2% and 50% of the control group data, respectively.

According to the algorithm of the electrophysiological studies of patients with suspected peripheral nerve lesion, established at the Research Institute of Traumatology, Orthopedics, and Neurosurgery of the Saratov State Medical University, a needle EMG is performed after ENMG to identify signs of impaired motor innervation. Active denervation processes in the muscles of the thigh and lower leg were contraindications of TEP, regardless of the ENMG results. Thus, in the course of the studies in two patients, the M-responses of the peroneal and tibial nerves were reduced and did not exceed 1.2 and 3.5 mV, respectively. Needle EMG showed denervation activities (fibrillation potentials and positive sharp waves) in both heads of the biceps muscle of the thigh in the anterior tibial and gastrocnemius muscles. Since the ENMG and EMG signs of the lesion of both regions of the SN showed impaired motor innervation at the thigh and lower leg levels, TEP was postponed, and the patients were transferred to the neurosurgery department.

Along with quantitative indicators, the shape of the F-wave curves was assessed to study the afferent–efferent conductivity of the proximal segments of the nerves and roots of the spinal cord. Between the M-response and F-waves, additional, fixed early responses were recorded along both or one of the nerves, as A-waves with a latent period spread from 17 to 21 ms or in the form of polyphase complexes.

A-waves were more often recorded along the tibial nerve on the side of the greatest joint lesion with limb shortening of ≥3 cm or in 11 patients of group 1 (16%) and 6 (50%) patients of group 2. Repeated ENMG at early stages after the joint implantation was performed according to indications in six patients with dysplastic coxarthrosis who complained of parasthesia and decreased sensitivity along the anterior surface of the leg. The decrease in ENMG parameters did not exceed 10% of the initial data, despite the recorded A-wave in 5 of 6 patients before surgery. On day 2, one female patient with post-traumatic arthrosis of the HJ developed pain on the rear side of the thigh and weakness on dorsiflexion of the operated side of the foot. The M-response of the peroneal nerve did not exceed 0.8 mV, and F-waves were absent. The ENMG data obtained before surgery showed an M-response with an amplitude of 1.4 mV, which indicated axonal damage to the peroneal portion of the SN, but without

**Table 2.** Indicators of electroneuromyography of the peroneal and tibial nerves in patients with post-traumatic coxarthrosis

| Nerve (*n* = 10), side | LP, ms | Amplitude, mV | Conduction block, % | SICeff, m/s | F-wave, ms |
|---|---|---|---|---|---|
| Малоберцовый, больная | 3,2±0,8 | 2,4±0,9*# | 44,0±11,1**,## | 43,7±3,1 | 43,6±2,9 |
| Здоровая | 2,9±0,2 | 4,8±0,8 | 15,1±0,4 | 57,3±6,7 | 38,2±3,4 |
| Контрольная | 2,9±0,3 | 5,1±0,8 | 9,6±6,6 | 52,9±4,8 | 41,9±4,7 |
| Большеберцовый, больная | 3,5±0,5^^^ | 4,9±1,7^ | 32,5±11,7^^ | 52,7±3,8 | 47,5±3,7 |
| Здоровая | 3,0±0,8 | 9,7±2,4 | 52,4±2,8^^ | 48,7±3,5 | 44,7±2,7 |
| Контрольная | 2,9±0,5 | 9,4±1,3 | 9,0±6,7 | 55,8±4,2 | 45,6±3,8 |

*Note.* LT — latent time, SICeff — speed of impulse conduction along motor fibers.
*Significance of differences between the values of the affected and healthy sides of the peroneal nerve, $p$ <0.002, **$p$ <0.03; #reliability of differences between the values of the affected side and the data of the control group of the peroneal nerve, $p$ <0.0002, ##$p$ <0.003; ^reliability of differences between the values of the affected and healthy sides of the tibial nerve, $p$ <0.0002, ^^$p$ <0.01, ^^^$p$ <0.002.

EMG signs of impaired motor innervation. Despite the ongoing physiofunctional and drug treatment based on ENMG and EMG monitoring, an increase in denervation disorders was evident within 1 month; the patient underwent SN neurolysis, followed by direct electromodulation.

Repeated ENMG performed 1 month after the implantation of the HJ in 64 patients of group 1 and 10 patients in group 2 did not reveal significant differences in ENMG data. The indices of the M-responses of the peroneal nerve were 3.5 ± 1.7 mV in the initial examination and 3.8 ± 1.3 mV in another examination. A moderate decrease in the amplitudes of M-responses, not exceeding 23% of the primary data, was noted mainly in group 2.

## DISCUSSION

Analysis of the results of patients with dysplastic coxarthrosis showed that in 28% of the patients, a significant decrease in the peroneal nerve indices in comparison with the norm and contralateral limb data, indicating the presence of an axonal lesion, was noted on the side of the forthcoming TEP. Similar changes were recorded in patients who had undergone surgery for congenital dislocation of the HJ. The results correspond to the literature data that TEP has more frequent neurological complications in patients who underwent surgical treatment of HJ deformities during childhood. A decrease in the conduction properties of the proximal segment of the tibial nerve at the femur level in 86.8% of the cases and the asymmetry of the conduction times >2 ms at the L5 and S1 root level of the spinal cord in 43 of 68 patients indicated the presence of radicular disorders confirmed by the radiation diagnostics data.

In patients with post-traumatic arthrosis of the HJ, on the side of the affected joint, ENMG signs of predominantly axonal damage of not only the peroneal but also the tibial nerves were associated with traction and compression–ischemic lesions of the SN during trauma. The need for an electrophysiological study before TEP in such patients is also indicated by the asymptomatic course of the denervation processes in the thigh and lower leg muscles, identified by needle EMG. The presence of the axon reflex revealed during the study of the F-waves in 11 patients with HJ dysplasia and in six patients with post-traumatic coxarthrosis with limb shortening >3 cm indicated local branching of the axons in response to nerve compression and the presence of a locally affected area [3]. We regarded the A-wave as an ENMG sign of a local lesion of both or one of the SN regions.

Repeated ENMG 1 month after TEP did not reveal any negative changes over time in the ENMG data of both nerves in most cases, as a result of changes detected in electrophysiological data on the state of the SN in the preoperative period. However, it is not always possible to avoid neurological complications during HJ implantation in severe joint deformities [21, 22]; moreover, timely ENMG monitoring contributes to the restoration of the nerve conduction function. In the postoperative and rehabilitation periods, when the load on the operated limb increases, knowledge about the level and extent of nerve damage will help avoid an increase in pain syndrome and adjust individually the patient's rehabilitation program.

## CONCLUSION

ENMG in patients with DA of the HJ in the preoperative period revealed the already existing signs of axonal lesions of predominantly the peroneal nerve, ENMG signs of local lesions of one or both portions of the SN, a decrease in the conduction function of the proximal segments of the tibial nerve, and signs of progressive neuropathy in patients with post-traumatic coxarthrosis. The results of electrophysiological diagnostics help in predicting the functional risk of neurological complications after TEP.

## ADDITIONAL INFO

**Author contribution.** S.P. Bazhanov, V.V. Ostrovskij — concept and design of the research; G.A. Korshunova — data collection and processing, writing; V.S. Tolkachev — statistical analysis; V.V. Ostrovskij, A.A. Chekhonatsky — editing. Thereby, all authors made a

substantial contribution to the conception of the work, acquisition, analysis, interpretation of data for the work, drafting and revising the work, final approval of the version to be published and agree to be accountable for all aspects of the work.

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**Competing interests.** The authors declare that they have no competing interests.

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