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ORIGINAL ARTICLE

Restoration of the function of the sciatic nerve and its branches after trauma

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ABSTRACT

Aim To investigate the efficacy of various methods for restoring the sciatic nerve and its branches after traumatic injuries to develop optimal treatment strategies, improve functional outcomes, and enhance patients' quality of life.

Methods A retrospective cohort study was conducted at the Neurosurgical Centre of Almaty, Kazakhstan, based on City Clinical Hospital No. 7. From 2013 to 2022, 227 patients with sciatic nerve lesions and their branches were operated. The proportion of patients of working age was 93.8%. Over half of the patients were hospitalized more than six months after the injury.

Results A high and satisfactory level of functional recovery after the surgical treatment of the sciatic nerve and its branches was achieved in 173 (77.5%) patients, with partial improvement in 21 (9.4%) and no significant improvement in 30 (13.1%). Two-stage restoration of the sciatic nerve function in cases with diastasis of more than 5 cm improved treatment results in 202 (89.2%) patients contributing to the restoration of motor function and gait within two to three years.

Conclusion When repairing the sciatic nerve with extensive defects, the tibial nerve is prioritized over the peroneal nerve due to better regeneration. Nerve autoplasty is preferred because of the rigidity of the sciatic nerve trunk and significant muscle load. For diastasis over 7 cm, the peroneal nerve trunk can be used for tibial nerve plasty. Two-stage reconstruction involves tendon-muscle plasty after signs of tibial nerve conduction appear, restoring motor function and gait and improving the patient's quality of life.

Keywords: nerve regeneration, nerve transfer, peripheral nerve injuries, sciatic nerve

INTRODUCTION

Peripheral nerve (PN) injuries, predominantly traumatic, are the most common among PN pathologies accounting for 1.8-2.8% of limb injuries, with 23-40% of cases occurring in the lower extremities (1). Injuries to the sciatic nerve (SN) and its branches account for over one-third of all cases. The SN is the largest and longest nerve in the human body. In addition, its trunk is very strong and is subject to stretching during movements in the joints of the lower limb, including due to significant muscle strength (2). In this regard, surgical intervention often reveals a pronounced nerve diastasis associated with muscle stretching during movements, which increases with time (3). In addition to trauma, the prevalence of iatrogenic nerve injuries cannot be underestimated, accounting for 10-17% of all cases of nerve damage (4).

Currently, surgical treatment of sciatic nerve injuries emphasizes functional reconstruction methods, particularly when the nerve is completely damaged (5). The basic principles of diagnosis and treatment include early detection and surgical intervention. Special emphasis is placed on nerve reconstruction using nerve or tendon grafting (6). Many factors influence the outcome of peripheral nerve repair. Emergency operations are often performed by surgeons without sufficient instruments and experience, which are very important factors in this field (7). There is no clinically significant evidence of the benefits of using nerve repair devices over standard microsurgical techniques (8).

Researchers describe the efficacy of minimally invasive interventional techniques in pain management, opening new avenues for improving patient outcomes after peripheral nerve injuries (9). Research also continues on electro- and laser therapy in nerve tissue repair (10). The review emphasizes the effectiveness of physiotherapy techniques, including electrical stimulation, in treating sciatic nerve injuries (11). Successful recovery requires precise surgical intervention and advanced rehabilitation approaches (12). At the same time, current research into using nanomaterials for nerve tissue repair offers hope for further progress in treating peripheral nerve injuries (13). Scientific research continues to focus on the diagnosis, treatment, and rehabilitation of patients with peripheral nerve

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injuries, and the development of new techniques and technologies contributes to improving functional outcomes and patients' quality of life (14). Modern research shows that it is possible to restore peripheral nerves through surgical intervention and additional therapeutic methods (15). Hyperbaric oxygenation can accelerate the recovery of peripheral nerves, especially in upper extremity injuries (16). Research aimed at developing new methods of neurosurgical reconstruction also plays an important role in improving functional outcomes (17). The effect of time elapsed from injury to surgery on brachial plexus nerve recovery confirmed the importance of timely intervention for positive outcomes (18). In addition, using sural nerve grafts in digital nerve reconstruction demonstrates long-term results (19). Additionally, methods such as electrotherapy to stimulate nerve regeneration and electro-influence on recovery processes are being investigated (20). Thus, the accumulated evidence on the treatment of peripheral nerve injuries demonstrates a wide range of opportunities to improve regenerative processes through the application of innovative therapeutic methods and technologies, which ultimately contribute to improving patients' quality of life (21).

The aim of this study was to investigate the efficacy of various methods for restoring the sciatic nerve and its branches after traumatic injuries to develop optimal treatment strategies, improve functional outcomes, and enhance patients' quality of life.

PATIENTS AND METHODS

Patients and study design

In this retrospective cohort study, following the inclusion and exclusion criteria, 227 patients with sciatic nerve (SN) lesions with various limb injuries were included and operated on from January 2013 to December 2020 in the Neurosurgical Centre of City Clinical Hospital No. 7 in Almaty, Kazakhstan.

Inclusion criteria were the patients who had a destructive lower limb injury with a complete follow-up period of at least 12 to 24 months. Exclusion criteria were the patients with severe brain, chest, and abdominal injuries that would complicate recovery, time of limb ischemia of more than 8 hours, and associated with severe diabetes, hypertension, heart disease, or other conditions or other systemic diseases (e.g., chronic kidney disease, cancer, or cirrhosis) that could impair nerve regeneration and wound healing.

In our analysis of patients with sciatic nerve lesions, we utilized both standard age ranges and the World Health Organization (WHO) (22) age classification to better understand patient demographics and treatment outcomes. These ranges provide a focused breakdown of the younger population, where trauma-related nerve injuries are more prevalent, especially due to physical activities, accidents, or sports injuries. It helps in tracking trends across specific age intervals relevant to the clinical focus. The WHO classification is broader, giving insights into general health trends and comparing the burden of injury in different life stages. It provides global relevance and helps align findings with public health data.

Using both approaches allowed us to assess trends specific to certain age ranges while also maintaining consistency with international standards, facilitating better communication of results and comparison with other studies.

A written consent was obtained from all participants. The ethics committee of the Local Ethical Committee of the Kazakh National Medical University approved this study (No. 12, 27 March 2023).

Methods

The diagnostic complex included stimulation and needle electroneuromyography (ENMG), ultrasound, and magnetic resonance imaging (MRI) of the peripheral nerves, in detail, typically MRI myelography. Medtronic Neurophysiological Intraoperative Monitoring (NIM) (Eclipse, Minneapolis, Minnesota, USA) was used during surgery to monitor neurophysiological potentials. The microsurgical method (operating microscope Carl Zeiss Opmi Vario s88 (Carl Zeiss AG, Oberkochen, Germany), was used in all operated patients.

Function and integrity of peripheral nerves and muscles. The function and integrity of peripheral nerves and muscles were evaluated by electroneuromyography (ENMG) (23). It involves two main components. Nerve Conduction Studies (NCS): This component assesses the speed and strength of electrical signals as they travel through peripheral nerves. It provides information about the conduction velocity and amplitude, which are indicators of nerve health and function. Electromyography (EMG): This component evaluates the electrical activity in muscles at rest and during contraction. It helps in identifying abnormalities in muscle response that may be due to nerve or muscle pathology. These two components combined allow for a comprehensive evaluation of the neuromuscular system, helping to diagnose and assess conditions related to nerve damage or muscular dysfunction

A measurement of nerve conduction velocity (NCV) is used to assess how well electrical signals travel along the nerve. Reduced conduction velocity or blocked signals can indicate nerve compression, injury, or demyelination and help localize the lesion by testing sensory and motor nerves. It involves inserting a needle electrode into specific muscles to detect spontaneous electrical activity or abnormal responses and identifies denervation signs such as fibrillations and positive sharp waves, indicating axonal damage. It is useful in monitoring recovery, as reinnervation signs (e.g., polyphasic potentials) suggest nerve regeneration (24).

Magnetic Resonance Imaging (MRI) is not a component of Nerve Conduction Velocity (NCV) testing. MRI and NCV serve different diagnostic purposes, though they are often complementary in evaluating nerve injuries. NCV measures how fast electrical impulses travel through a nerve, and is used to assess peripheral nerve function and detect conditions like neuropathy or nerve compression, often performed alongside Electromyography (EMG) to assess both nerve and muscle function. MRI provides high-resolution images of soft tissues, including nerves, muscles, and surrounding structures, and helps visualize anatomical abnormalities, such as herniated discs or nerve entrapment, that might be causing nerve dysfunction. MRI is especially useful for assessing deeper nerves and ruling out structural causes of injury. While NCV focuses on electrical conduction, MRI complements it by offering anatomical details, helping to localize and better understand the nature of the injury. Together, they give a more comprehensive view of nerve health.

Magnetic resonance neurography (MRN) is a specialized type of MRI designed to produce detailed images of the peripheral nerves and surrounding tissues, in order to visualize peripheral nerves and surrounding tissues highlighting nerves (the sciatic, peroneal, and tibial), and enable the identification of nerve compression, entrapment, or inflammatory changes, as well as neuromas (nerve tumours) and post-traumatic scarring. Also, MRI provides soft tissue visualization to detect related injuries, such as muscle edema, hematomas, or bone fractures, which can indirectly affect nerve recovery (25).

Magnetic Resonance Imaging (MRI) Myelography (26) was used to focus on imaging of the spinal cord and nerve roots by capturing the flow of cerebrospinal fluid (CSF) without requiring contrast agents. It is particularly useful to rule out nerve root compression, disc herniation, or other spinal pathologies contributing to peripheral nerve dysfunction.

Neurophysiological intraoperative monitoring (NIM) (Eclipse by Medtronic, Minneapolis, USA) is used for the monitoring of motor and sensory potentials during surgery to prevent intraoperative nerve damage. Real-time feedback helps guide the surgeon during dissection and nerve manipulation. It ensures intact nerve function through electromyographic (EMG) and evoked potential monitoring (27).

Nerve autoplasty (sciatic nerve reconstruction) (28) refers to the use of a nerve graft, usually harvested from the patient's own body (e.g., the sural nerve), to bridge the gap in a damaged nerve. This technique helps restore continuity and facilitates axonal regeneration. Nerve dissection: the injured section of the sciatic nerve was identified, and any damaged tissue was excised to create clean, healthy ends. In the case of graft harvesting, the sural nerve was typically used, as it is expendable and provides good length for reconstruction.

Graft placement. The harvested nerve segment was carefully sutured to the proximal and distal ends of the sciatic nerve using microsurgical techniques with fine sutures (8-0, 9-0). An operating Microscope (Carl Zeiss OPMI Vario S88) was used to ensure microsurgical precision. Microsurgical instruments (Aesculap, B. Braun, uttlingen, Germany), provide gentle handling to minimize trauma to the nerve. Nerve grafts act as a guide for regenerating axons to reconnect with their target tissues (29).

Post-surgical monitoring is essential to assess nerve regeneration using electroneuromyography (ENMG) over time. Tendon-muscle plasty aims to restore lost motor function by transferring tendons or muscles to compensate for the paralyzed or weakened structures due to nerve injury. This is essential for maintaining foot mobility and function in cases of sciatic nerve damage (30). The identification of target muscles and tendons, key muscles affected by sciatic nerve injury includes the hamstrings and foot flexors/extensors.

Healthy tendons (often from nearby muscles) were mobilized and reattached to compensate for the paralyzed muscles.

Tendons were secured using fine sutures and monitored for tension to ensure proper muscle alignment and function.

Post-surgical care included immobilization and intensive physiotherapy to prevent contractures and optimize functional recovery.

Restoration methods. Nerve Autoplasty, Nerve Dissection and Resection, Tendon-Muscle Plasty, Neurophysiological Intraoperative Monitoring (NIM) restoration methods can be used in isolation or combination, depending on the specific type of nerve injury, the extent of damage, and the patient's overall health and rehabilitation goals. Collaboration among surgeons, physiotherapists, and occupational therapists is essential for effective recovery.

With a nerve defect of >7 cm, taking into account the irrecoverable lesion of the peripheral nerve (PN) or its portion, a part of the PN for plasty of the PN defect was used.

Medical Research Council (MRC) muscle scale (31) grades muscle power on a scale of 0 to 5 in relation to the maximum expected for that muscle, by 12 to 18 months after the first operation.

An ordinal scale score provides a rough indication of the severity of lesions (nerve injury) based on clinical judgement. It reflects how mild or severe the lesion is in all cases studied. The score 1.0 means that all lesions were mild, 2.0 means that the lesions were moderate on average, 3.0 means the injuries were severe in all cases.

The mean 1.60 ± 0.08, this indicates that the overall severity level is skewed towards mild to moderate, but there is variability ($\pm$ 0.08) which reflects the standard error of the mean (SEM).

Complexity score for surgical interventions system ranks procedures based on their difficulty and specialization: 1 = Simple procedure, 2 = Mild complexity, 3 = Moderate complexity, 4 = High complexity, 5 = Very high complexity / highly specialized. Mean complexity score: 3.88, standard deviation (SD): $\pm$ 0.23, this average score suggests that the interventions performed in our dataset generally fall between moderate (3) and high complexity (4). The SD of 0.23 reflects some variability, meaning most cases are relatively consistent around this level of complexity. The Complexity score for anatomical location provided assigns increasing difficulty based on: simple area - easy to access and treat (e.g., superficial nerves, fewer vital structures), mild complexity - moderate depth or structure density (e.g., subcutaneous tissues), moderate complexity - structures require careful dissection (e.g., nerves near muscles), high complexity - close proximity to major vessels or critical nerves, requiring precision, very high complexity - areas with dense anatomy or hard-to-reach structures, needing highly specialized skills and care. Mean score: 4.12, standard deviation (SD): $\pm$ 0.21, this score suggests that most anatomical locations in our study are highly complex (around level 4), requiring advanced skills to access and treat effectively. The low variability ($\pm$ 0.21) indicates that the majority of the cases are consistently complex across different anatomical sites, with relatively little variation.

Binary Scale for Body Side assigns a value based on the side of injury: 1 = left side injury, 2 = right side injury. This type of scale is binary since only two possible outcomes (left or right) are measured. The mean score of 1.36 ± 0.03 on the binary scale indicates that more injuries occurred on the left side. Although both sides are affected, the slight skew towards the left (55.6%) may point to anatomical, behavioural, or occupational patterns leading to this imbalance. The low SD suggests consistent patterns in the side of injury across your dataset.

Custom Ordinal Scale for Body Part Severity is designed to measure the severity of injury or the impact on the affected body part: 1 = mild severity (minimal dysfunction),

2 = moderate severity (some functional limitation), 3 = severe impact (significant loss of function), 4 = very severe or complete loss of function (e.g., paralysis or complete immobility). The mean score of 2.31 ± 0.22 on the custom ordinal scale indicates that the injuries involve moderate to severe functional impairment, with most cases not yet reaching complete loss of function. This score reflects the seriousness of the injuries across both upper (61.1%) and lower (38.9%) body parts, helping inform treatment decisions and rehabilitation planning.

The second stage of surgical reconstruction in cases of sciatic nerve injury or similar peripheral nerve injuries often involves tendon-muscle plasty. This procedure typically aims to restore the function by transferring the flexor muscles to the extensor position of the foot, thereby compensating for the loss of function due to the damaged nerve.

Statistical analysis

The numerical, continuous values were represented as mean, and categorical variables were presented as numerical values and percentages. Descriptive statistics, contingency tables, comparison of means with univariate t-criterion, ANOVA, correlation, nominal regression, and Mayer Kaplan were used. Baseline characteristics were expressed as mean ±standard deviation (SD), or number (%). All hypotheses were two-sided, and p <0.05 was considered statistically significant. Data were checked for missing values and data entry errors before analysis.

RESULTS

Patients ranged in age from 16 to 84 years (mean age 35.6 years). Most of the patients with nerve injuries were hospitalized at a non-optimal time for nerve regeneration, 114 (50.0%). The study included 227 patients, with a large gender imbalance, 171 (75.3%) males and 56 (24.7%) females (Figure 1). The majority of the patients were young individuals; 188 (83.0%) were between the ages of 16 and 30. A significant number of surgeries 757 in total, were performed during the study, with 226 (29.9%) involving the sciatic nerve and its branches. A notable number of the patients were of working age, 213 (93.8%), between 16 and 60.

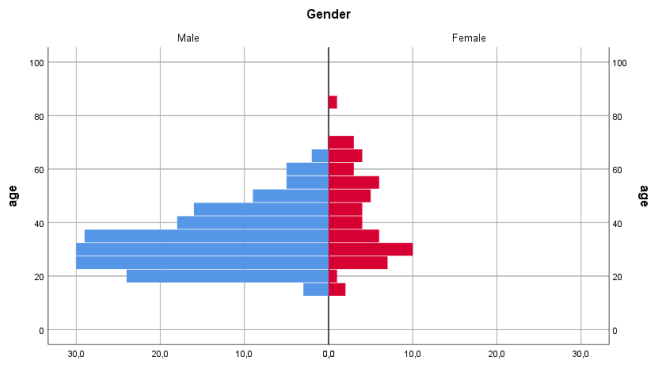

Figure 1. Distribution of patients by gender and age

Sciatic nerve treatment outcome was not highly dependent on the patient's gender (mean ±SD=1.25 ± 0.029 years) (p=<0.045).

The patient age almost reached statistical significance, indicating a potential influence on treatment outcomes, though not decisive in this study (mean ±SD=35.88 ± 0.87 years) (p<0.051).

The WHO age classification (22) had no significant effect on treatment outcomes suggesting that age was not a critical factor for nerve repair (mean ±SD=1.30 ± 0.04 years) (p=0.05), meaning the true population mean was likely within the interval 1.26 to 1.34 with some degree of confidence. This suggests a relatively small variation.

The diagnosis, although not highly significant (p<0.004), was crucial for understanding the patient's condition and damage types. The mean ±SD=3.28 ± 0.16 score according to MRC scale suggests a moderate level of impairment or injury among patients, with low variability (SD = 0.16) in severity.

Involvement of tibial and peroneal nerves significantly affected the outcome, emphasizing the importance of nerve damage specificity; a mean ±SD=1.60 ± 0.08 possibly measured on a ordinal scale suggested the most patients had moderate nerve involvement, with minimal variability in outcomes across the sample (p<0.004) (Table 1).

According to the ordinal scale score on the severity of the lesion (nerve injury) based on clinical assessment, the mean value is 1.60 ± 0.08, this indicates that the overall severity level is skewed towards mild to moderate, but there is variability (± 0.08) which reflects the standard error of the mean (SEM).

The surgical complexity scoring system showed that the mean complexity score: 3.88, standard deviation (SD): ± 0.23, this average score suggests that the interventions performed in our dataset generally fall between moderate (3) and high complexity (4). The SD of 0.23 reflects some variability, meaning most cases are relatively consistent around this level of complexity.

The complexity score for anatomical location the mean score: 4.12, standard deviation (SD): ± 0.21, this score suggests that most anatomical locations in our study are highly complex (around level 4), requiring advanced skills to access and treat effectively. The low variability (± 0.21) indicates that the majority of the cases are consistently complex across different anatomical sites, with relatively little variation.

The binary scale for the side of the body showed that a mean score of 1.36 ± 0.03 on the binary scale indicated that more injuries occurred on the left side. Although both sides are affected, a slight bias towards the left side (55.6%) may indicate anatomical, behavioural, or occupational characteristics leading to this imbalance. The low SD indicates that patterns of injury side are evident throughout the data set.

The mean score of 2.31 ± 0.22 on the custom ordinal scale indicates that the injuries involve moderate to severe functional impairment, with most cases not yet reaching complete loss of function. This score reflects the seriousness of the injuries across both upper (61.1%) and lower (38.9%) body parts, helping inform treatment decisions and rehabilitation planning.

The gluteal area on the left side had the highest frequency, 95 (42.1%) patients, followed by the shin and toes on the right side, 53 (23.3%) patients. The shin and foot on both sides had the lowest frequency, with two (0.8%) patients each (Figure 2).

Sciatic nerve impingement was the most common diagnosis in both males and females, though significantly higher in females, 29 (out of 56; 51.8%) compared to males, 60 (out of 171; 35.3%). Complete disruption of the sciatic nerve was more

Table 1. Baseline data of patients with sciatic nerve lesion

Variable		No (%) of patients	N	Mean ±SD	p
Year of surgery (Mean years since surgery at follow-up)	2013-2022		227	5.67 ± 0.18	0.000
Gender	Male Female	171 (75.3) 56 (24.7)	227	1.25 ± 0.029 (1=Male, 2=Female)	0.045
Age (years)	16-20 21-30 31-40 41-50 51-60	62 (27.3) 126 (55.5) 21 (9.2) 13 (5.7) 1 (0.4)	227	35.88 ± 0.87	0.051
Age by WHO	Adolescents (10–19 years) Young adults (20–24 years) Adults (25–44 years) Middle-aged adults (45 -59 years) Older adults (60+ years)	35 (15.4) 68 (30.0) 89 (39.2) 21 (9.3) 14 (6.2)	227	1.30 ± 0.04	0.05
Diagnosis	Sciatic nerve impingement Complete disruption of the sciatic nerve Damage Tunnel neuropathy Neuropathy Traction compression Partial tear of the sciatic nerve Implications Intraneural ganglia	85 (37.6) 55 (24.4) 30 (13.3) 25 (11.1) 15 (6.6) 10 (4.4) 5 (2.2) 1 (0.4) 5 (2.2)	226	3.28 ± 0.16*	0.004
Tibial/peroneal nerve damage	Tibial Peroneal Tibial and peroneal	42 (50.0) 32 (38.1) 10 (11.9)	84	1.60 ± 0.08†	0.05
Paresis	Profound Flexor and extensor palsy Extensor paresis Flexor muscle palsy Gross paresis Flexor palsy	12 (35.3) 8 (23.5) 6 (17.6) 4 (11.8) 3 (8.8) 1 (2.9)	34	4.38 ± 0.38*	0.007
Paralysis	Foot extensor muscle paralysis Lower limb muscle palsy Flexor muscles of the left thigh and lower leg Tibial flexor and extensor	62 (44.9) 40 (29.0) 26 (18.8) 10 (7.2)	138	1.60 ± 0.59*	0.003
Pain syndrome	Pain causalgia Pain neuropathic	20 (52.6) 18 (47.4)	38	2.13 ± 0.15†	0.000
Operation	Exoneurolysis Exo-endoneurolysis Endoneurolysis Microsurgical autoplasty Microsurgical partial autoplasty	80 (35.4) 50 (22.1) 40 (17.7) 36 (15.9) 20 (8.8)	226	3.88 ± 0.23‡	0.000
Localization	Gluteal area Thigh Thigh+shin Gluteal and thigh area Shin and toes	80 (38.5) 60 (28.8) 35 (16.8) 25 (12.0) 8 (3.8)	208	4.12 ± 0.21§	0.001
Bodyside	Left Right	115 (55.6) 92 (44.4)	207	1.36 ± 0.03 II	0.015
Body part	Upper Lower	22 (61.1) 14 (38.9)	36	2.31 ± 0.22¶	0.001

*based on Medical Research Council (MRC) muscle scale: 0–5 (0=none, 5=normal); †Ordinal scale score: 1 = Mild, 2=Moderate, 3=Severe); ‡Complexity Scale for surgical intervention: 1 = Simple procedure, 2 = Mild complexity, 3 = Moderate complexity, 4 = High complexity, 5 = Very high complexity / highly specialized; §Complexity Scale for Anatomical Location: 1 = Simple area to access and treat, 2 = Mild complexity, 3 = Moderate complexity, 4 = High complexity (e.g., structures close to important vessels or nerves), 5 = Very high complexity; II Binary Scale for Body Side Paralysis: 1 = Left side injury, 2 = Right side injury; ¶Custom Ordinal Scale: 1 = Mild severity, 2 = Moderate severity, 3 = Severe impact, 4 = Very severe or complete loss of function

N, number of the patients; WHO, World Health Organization;

The World Health Organization (WHO) coding for gender is a standardized system to categorize individuals by gender for data collection and analysis. In this case, we are talking about the Mean ±SD

prevalent in males, 30 (out of 171; 17.6%) than in females, three (out of 56; 5.4%) patients (p= <0.024). Neuropathy had a slightly higher occurrence in females (19.6%) than in males (15.9%). Diagnoses such as tunnel neuropathy and intraneural ganglia showed relatively small differences between genders. Damage appears only in males (3.5%) and not in females (Figure 3).

The results showed the predominance of autoplasty (AP) over the suturing of the sciatic nerve (CN) and its branches, more than fourfold, which can be explained by the stiffness of

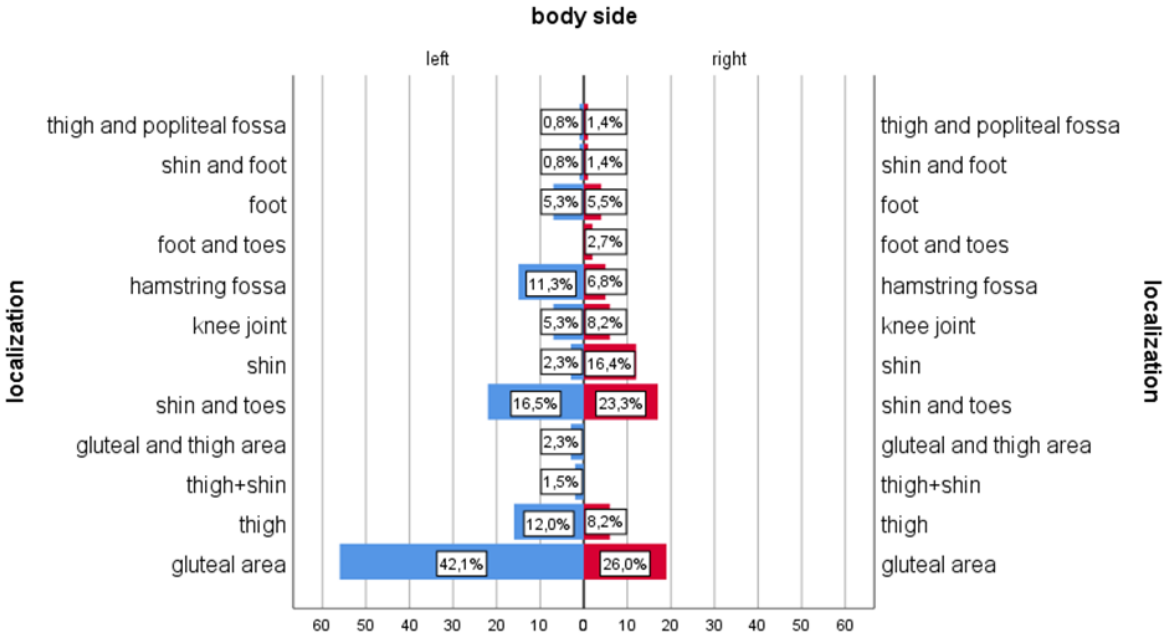

Figure 2. Localization according to the side of the body of patients

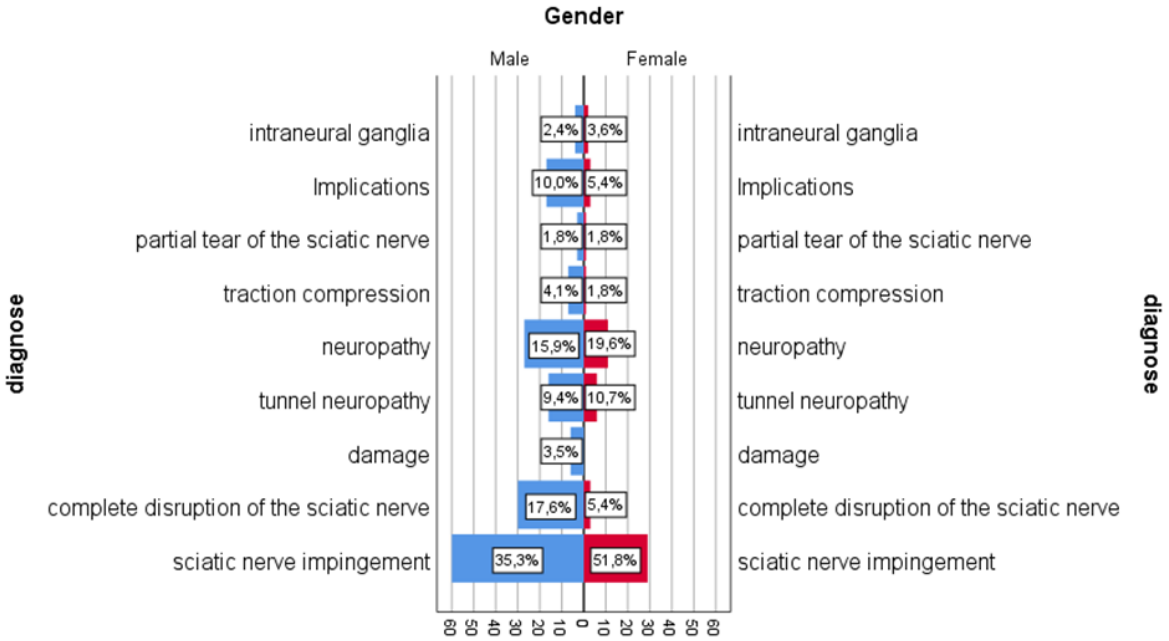

Figure 3. Diagnoses of patients with sciatic nerve damage by gender

the CN with visible nerve tension throughout. Suture placement was preferable in the area of the popliteal fossa, but even here, given the powerful strength of the muscles when extending the knee joint, we cannot guarantee sufficient strength of the suture and successful regeneration of the nerve. No particular difference in the results of suturing and autoplasty was observed, although larger defects took longer to regenerate the nerve (Figure 4).

In our observation, we achieved plantar flexion of the foot of grades 2 to 3 according to the Medical Research Council (MRC) scale 12 to 18 months after the first operation.

The second stage was tendon-muscle plasty - switching the flexor muscles to the extensor position of the foot. After that, restoration of the useful function of the lower extremity was observed in 89.2% of patients with the restoration of the motor stereotype of the gait.

DISCUSSION

During the study period, 757 operations were performed, with operations on the sciatic nerve and its branches accounting for 29.9%. These results underscore the significance of sciatic nerve pathology and highlight the necessity for developing effective diagnostic and treatment methods to enhance outcomes for patients suffering from such injuries. Notably, 93.8% of the patients were of working age (16 to 60 years), indicating

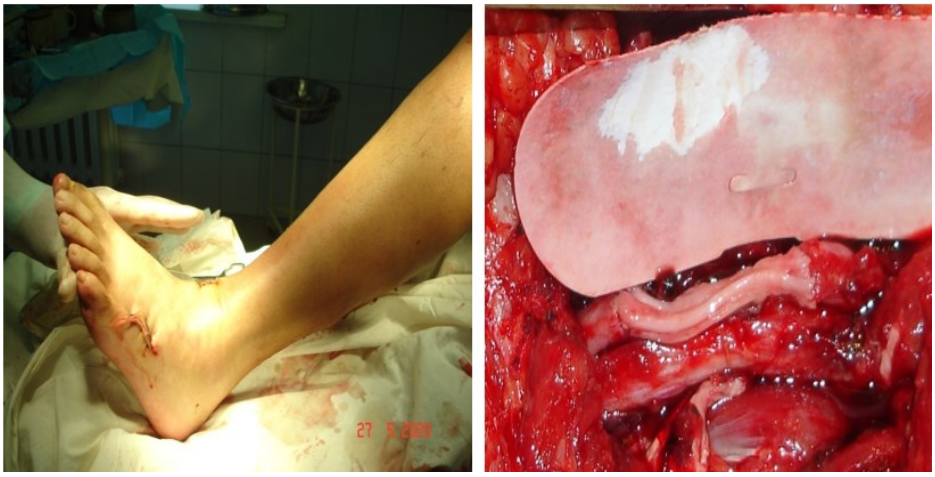

Figure 4 . Aautoplasty of the sciatic nerve depicts a surgical site involving the sciatic nerve, likely showing the process of autoplasty (left) and the result of tendon-muscle plasty (right) (The Neurosurgical Centre of City Clinical Hospital No. 7, Almaty, Kazakhstan, 2022)

that conditions related to the sciatic nerve predominantly affect younger individuals, particularly those in their prime working years. This demographic factor has substantial implications for productivity and quality of life. Therefore, it is essential to consider not only the medical aspects but also the economic ramifications of treating these patients. Restoring their ability to work can significantly decrease the costs associated with long-term medical care and disability benefits (32).

The study also revealed that other notable areas affected included the shin and toes on the left side (16.5%) and the shin on the right side (16.4%) indicating that certain diseases were more prevalent in specific regions. Comparative studies abroad show similar trends. A study conducted in the United States found that sciatic nerve injuries were more common in young adults and males, which is consistent with our data (33).

Some studies highlight the need for standardized assessment criteria in clinical examinations (34,35). Successful surgical intervention significantly improves functional outcome and quality of life of patients (36). Similarly, a study in Australia confirmed that early intervention and modern surgical techniques can reduce the risk of long-term complications and disabilities (37).

Integrating a multidisciplinary approach to the treatment of sciatic nerve injuries is very important. Patients who received comprehensive treatment that included physiotherapy and psychological support showed better long-term outcomes (38,39). The use of modern imaging techniques such as MRI and ultrasound facilitates more accurate diagnosis and surgical planning, which in turn improves treatment outcomes (40).

Our study indicates a pressing need for further research and the development of more effective strategies for preventing and treating sciatic nerve injuries. Particular attention should be paid to young adults, as this age group is most at risk (41). In addition, factors contributing to the higher prevalence of such injuries in males need to be investigated to develop targeted preventive measures. Thus, our study's results emphasize the importance of a multidisciplinary approach to treating patients with sciatic nerve injuries, including medical and socioeconomic support, which can significantly improve patient outcomes and quality of life. The worst results were observed after the gunshot and open penetrating wounds, not exceeding 50% of useful restoration of movements in the limb, mainly due to PN lesions (42,43).

Particular attention is paid to restoring the tibial nerve or its portions (44). With a nerve defect of more than 7 cm, taking into account the irrecoverable lesion of the PN or its portion, we used a part of the PN for plasty of the PN defect. Compared with the results of the previous decade, when only nerve reconstructions were performed (45), the percentage of useful recovery of movement and gait was 36.6% and partial recovery was 43.3%. Literature data indicate that nerve repair and tendon grafting patients showed better functional results (30,46).

Immune cells such as monocytes and macrophages have shown to play an important role in the nerve healing process. They are involved in the removal of dead cells through the epheriocytosis process, which promotes the resolution of inflammation and accelerates nerve tissue regeneration. These findings support the importance of a controlled inflammatory response for successful restoration of nerve function after injury (47). Different cytokines, such as IL-1RN and CXCL10, were found to show differential expression in injured nerves and dorsal root ganglia (DRGs), indicating the complex nature of the inflammatory response and the need for targeted intervention to optimize nerve regeneration. These data emphasize the importance of studying the molecular mechanisms of inflammation and their role in nerve repair (48).

A visual analysis of research trends showed that the main focus in the treatment of sciatic nerve injuries is regenerative medicine and neural tissue engineering (49). In recent years, there has been a significant increase in publications on the use of stem cells, electrical stimulation, pharmacologic interventions, and other innovative techniques to improve nerve function recovery (50). These studies emphasize the importance of a multidisciplinary approach and advanced technology to improve outcomes in treating sciatic nerve injuries.

In conclusion, for large sciatic nerve defects, tibial nerve autografting followed by tendon-muscle grafting to compensate for peroneal nerve function is optimal. For diastases over 7 cm, the peroneal nerve trunk can be used for tibial nerve grafting. Two-stage restoration has led to significant motor function and gait recovery within two to three years, improving quality of life. Autografting for defects larger than 3 cm is preferable to suturing. Suturing with knee flexion and immobilization can cause complications like nerve end divergence due to nerve rigidity and muscle strength. Timely treatment enhances functional recovery.

AUTHOR CONTRIBUTIONS

Conceptualization, A.K., Y.D. and M.M.; methodology, M.A., N.A.; software, D.B.; validation, S.I., and A.T.; formal analysis, A.K., Y.D.; investigation, M.M., M.A.; resources, N.A., S.I.; data curation, A.K., M.M.; writing-original draft preparation, A.K., Y.D. and M.M.; writing review and editing, N.A., D.B. and S.I., A.T.; supervision, S.I., project administration, A.T. All authors have read and agreed to the published version of the manuscript.

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