Case Report
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Treatment of Iatrogenic Nerve Injury After Humeral Shaft Fracture Fixation: A Case Report

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Abstract

Background. Iatrogenic neuropathies of the radial nerve following intramedullary nailing of the humerus are observed in 2.9% of patients. In 30% of cases, iatrogenic nerve injury is associated with distal nail locking. Questions about the timing and volume of diagnostic measures to determine the nature of nerve damage, methods of conservative and surgical treatment, and their effectiveness remain relevant.

Aim of the study — to present, through a clinical case, the causes, methods of prevention, diagnosis, and treatment of iatrogenic injuries to the radial nerve in cases of humeral fractures.

Case presentation. A 30-year-old female patient was admitted with a nonunion fracture of the left humerus and iatrogenic radial nerve injury three months after the fracture was fixed with a locking nail. A revision operation was performed: removal of the nail from the left humerus; re-fixation of the left humerus with a plate; revision, neurolysis, and plastic repair of the left radial nerve using autografts from the right sural nerve. Postoperative courses of medication therapy, physiotherapy, and therapeutic exercises were conducted. At 26 months after the surgery, complete range of motion and restoration of strength in active extension of the left wrist and three phalanges, abduction of the first finger, partial extension of the first finger, and restoration of sensitivity on the outer surface of the left forearm and the back of the hand were observed.

Conclusion. Iatrogenic radial nerve injury primarily occurs as a result of incorrect technique when introducing locking screws during intramedullary nailing of humeral shaft fractures. Delayed examination and surgical treatment of patients with injured radial nerve lead to a lack of full functional recovery, potential muscle atrophy, and impairment of their motor function. Surgical treatment aimed at restoring the radial nerve at an early stage after injury, combined with a full range of postoperative rehabilitation for a year, is the only correct treatment approach.

Keywords: iatrogenic injury, radial nerve, humerus fracture fixation.

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Клинический случай
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Лечение пациента с ятрогенным повреждением лучевого нерва после остеосинтеза плечевой кости: клинический случай

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Реферат

Актуальность. Ятрогенные нейропатии лучевого нерва после остеосинтеза диафиза плечевой кости штифтом с блокированием развиваются у 2,9% пациентов. При этом в 30% случаев ятрогенное повреждение нерва связано с дистальным блокированием штифта. Вопросы о сроках и объеме диагностических мероприятий, направленных на определение характера повреждения нерва, методах консервативного и хирургического лечения, их эффективности остаются актуальным.

Цель — на клиническом примере показать причины возникновения, методы профилактики, диагностики и лечения ятрогенных повреждений лучевого нерва при переломах плечевой кости.

Описание клинического случая. Пациентка 30 лет поступила с несросшимся переломом левой плечевой кости, ятрогенным повреждением лучевого нерва слева спустя 3 мес. после остеосинтеза перелома блокированным штифтом. Выполнена повторная операция: удаление штифта из левой плечевой кости; реостеосинтез левой плечевой кости пластиной; ревизия, невролиз, пластика левого лучевого нерва аутотрансплантатами из икроножного нерва справа. После операции проводили курсы медикаментозной терапии, физиотерапевтическое лечение, лечебную гимнастику. Через 26 мес. после операции наблюдали полную амплитуду и восстановление силы активного разгибания левой кисти и трехфаланговых пальцев, отведения первого пальца, неполную амплитуду разгибания первого пальца, восстановление чувствительности по наружной поверхности левого предплечья и тыльной поверхности кисти.

Заключение. Ятрогенное повреждение лучевого нерва происходит преимущественно в результате несоблюдения техники введения блокирующих винтов при остеосинтезе переломов диафиза плечевой кости штифтами. Несвоевременное обследование и оперативное лечение пациентов с поврежденным лучевым нервом приводит к невозможности полного функционального восстановления, потенциальной атрофии мышц, угнетению их двигательной функции. Оперативное лечение, направленное на восстановление лучевого нерва в ранние сроки после травмы, в сочетании с полным спектром послеоперационной реабилитации в течение года является единственно верным вариантом лечения.

Ключевые слова: ятрогенное повреждение лучевого нерва, перелом плечевой кости, остеосинтез плечевой кости.

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BACKGROUND

The problem of iatrogenic injuries to the radial nerve arising from the surgical treatment of humeral fractures remains relevant and significant [1, 2, 3, 4]. Questions regarding the timing and extent of diagnostic measures aimed at determining the nature of nerve injury, methods of conservative and surgical treatment, as well as their effectiveness, continue to be debated [5, 6, 7].

Aim of the study is to present, through a clinical case, the causes, methods of prevention, diagnosis, and treatment of iatrogenic injuries to the radial nerve in cases of humeral fractures.

Case presentation

A 30-year-old female patient sustained a closed diaphyseal fracture of the left humerus in January 2019 due to a fall. She was treated at a clinical hospital in one of the regions of the Russian Federation, where closed osteosynthesis of the left humerus was performed using a nail in the delayed postoperative period. During the early postoperative period, the patient experienced an absence of active extension of the left wrist and fingers. Iatrogenic radial nerve injury on the left side was diagnosed, and the patient underwent conservative treatment without improvement for 2.5 months.

She was subsequently admitted to our medical institution 3 months after the injury, complaining of pain in the left shoulder area and the inability to actively extend the left wrist and fingers.

Upon examination, minor soft tissue swelling was observed in the left shoulder and left wrist areas. Shoulder joint movements were limited due to pain. There was an absence of active extension of the left wrist and fingers (M0), abduction of the thumb (M0), and a sensory disorder along the external surface of the left forearm and hand in the area innervated by the superficial branch of the radial nerve (S0). Blood circulation in the fingers was normal.

X-ray examination revealed a fracture of the left humerus at the level of the middle third of the diaphysis after the osteosynthesis with a blocked nail, with no signs of consolidation. The nail extended 2 cm above the bottom of the medullary canal of the humerus, and the tip of the nail protruded 3 mm above the surface of the humeral head. Both distal blocking screws were inserted in a medial-to-lateral direction (Fig. 1).

The patient provided an ultrasound examination report of the left radial nerve, which indicated signs of compression and integrity violation of the radial nerve in the lower third of the shoulder in the area of the blocking screw, as well as swelling of the radial nerve trunk. Electroneuromyography (ENMG), including stimulation at the Erb's point, revealed complete functional block of neural conduction along the radial nerve on the left side (Fig. 2).

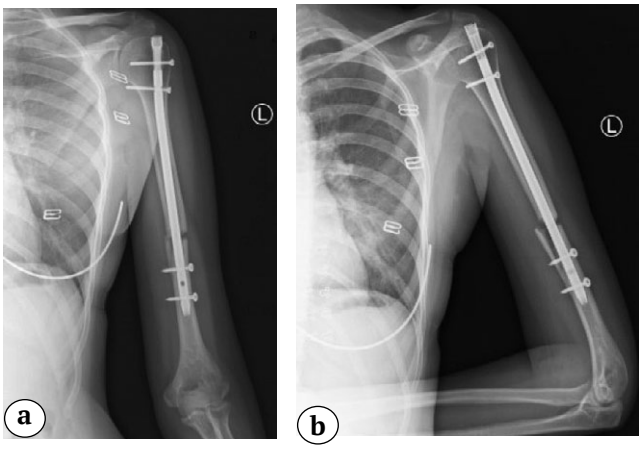
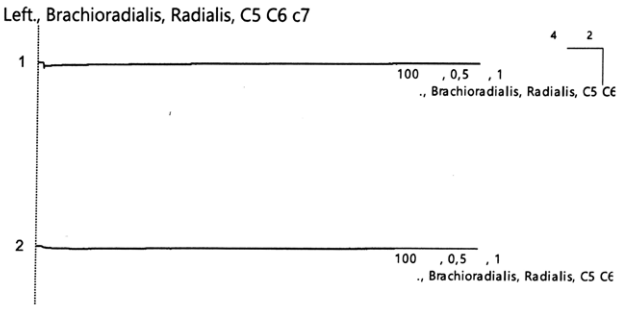


Fig. 1. X-rays after the left humeral bone nailing: a — anteroposterior view; b — lateral view



N	Stim. site	Dist., mm	Lat, ms	Amp mV
Left., Brachioradialis, Radialis, C5 C6 c7				
1	Elbow	60		**0**
2	Shoulder	100		0

Fig. 2. Preoperative electroneuromyography protocol

Three months after the injury, the patient underwent a repeat operation, which included the removal of the nail from the left humerus, re-osteosynthesis of the left humerus with a plate, nerve revision, neurolysis, and repair of the left radial nerve using autotransplantation of the sural nerve from the right side.

During the surgery, it was revealed that the radial nerve in the middle third of the humerus was embedded within scar tissue and interrupted at the contact point with one of the distal blocking screws. There was scar transformation of the nerve over a length of 4.0 cm, with a neuroma at the proximal end (Fig. 3).

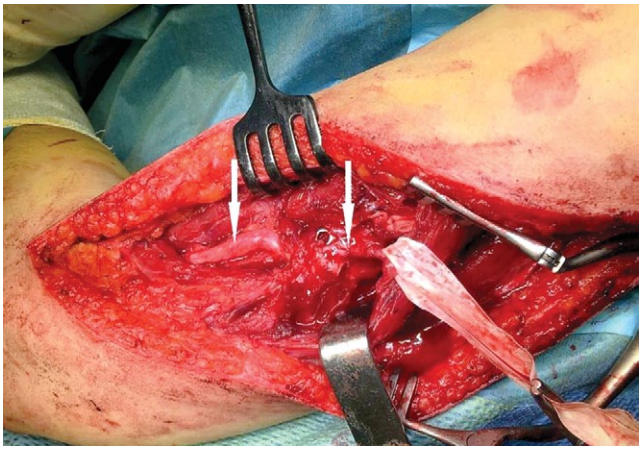


Fig. 3. A break in the radial nerve is identified (indicated by arrows) in the projection of the distal blocking screw; a neuroma at the proximal cult of the nerve

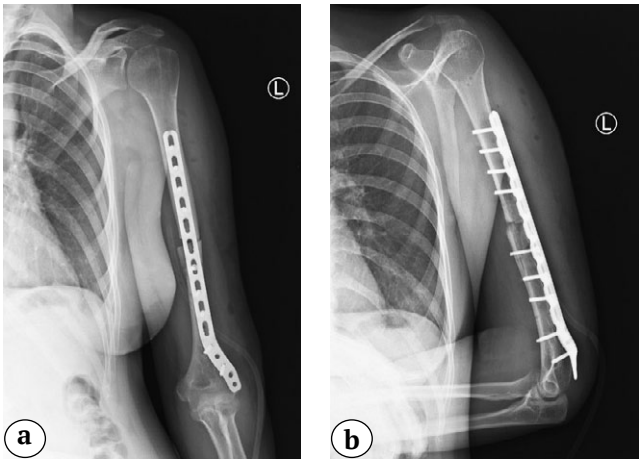


Fig. 4. X-rays after re-fixation of the left humeral bone with a plate; the position of the fragments and metal fixator is satisfactory:
a — anteroposterior view; b — lateral view

The nail was removed, and the fragments were extracted from the scar tissue, refreshed, aligned, and fixed with an extra-articular plate to achieve angular stability with compression (Fig. 4).

The scar-transformed segment of the radial nerve and the neuroma were excised. To repair the nerve defect, a sural nerve autograft was harvested from the right side. Four grafts, each 5 cm in length, were placed into the defect area. Using an operating microscope, an epineural suture was performed using Prolene 9/0 thread (Fig. 5).

The postoperative period was uneventful, and the patient was discharged from the hospital on the 9th day after the operation.

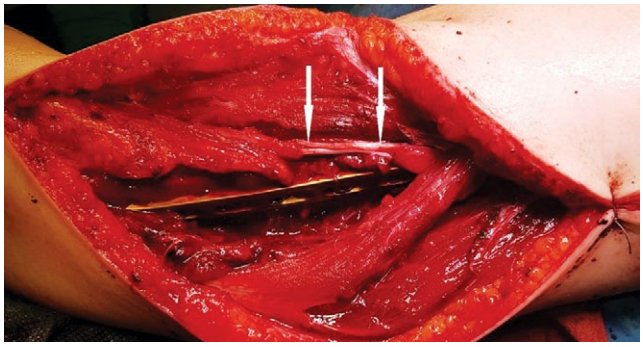


Fig. 5. Plating of the humeral bone, and radial nerve reconstruction using autografts (indicated by arrows)

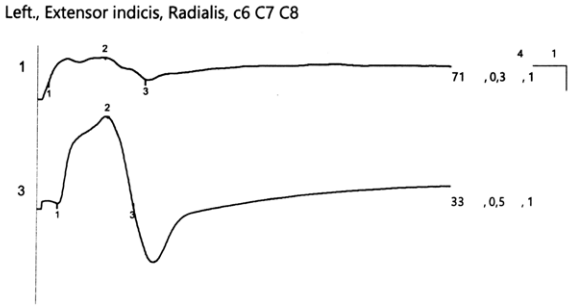
During the 11-month outpatient period, the patient received medical therapy and underwent physiotherapeutic treatment, including electromyostimulation, acupuncture, paraffin baths, mud therapy, massage, and therapeutic exercises involving passive and active finger and wrist movements.

According to the patient, positive recovery dynamics of the radial nerve began to appear 10 months after the operation, with the return of sensation in the external surface of the left forearm and dorsal surface of the wrist. After 13 months, the patient reported the ability to actively hold the wrist in a semi-physiological position without the assistance of an orthosis, with a slight amplitude of active extension of the three phalanges of the fingers, which further improved over time, followed by the restoration of active wrist extension. The function of active abduction of the first finger was restored

last, after 15 months. At the 18-month follow-up, the patient noted progressive improvement in fine finger motor skills.

At the 26-month follow-up after the operation, complete amplitude and restoration of strength in active wrist extension and three phalanges of the fingers (M5), as well as abduction of the first finger (M5), were observed. The amplitude of the first finger extension was not complete (M3–4).

ENMG data showed significant positive dynamics, with a low-amplitude M-wave and increased chronodispersion from the extensor indicis muscle and low-amplitude sensory nerve action potential upon stimulation of the superficial radial nerve (Fig. 6).



N	Stim. site	Dist., mm	Lat, ms	Amp mV	long., ms	Vel., m/s
Left., Extensor indicis, Radialis, c6 C7 C8						
1	midshoulder	60	1,4	1,0	11,6	
3	midshoulder	90	2,6	3,5	9,0	76,0

Fig. 6. ENMG protocol after 26 months post-operation

DISCUSSION

According to the analysis of the world literature, the frequency of iatrogenic radial nerve injuries ranges from 2% to 17% [8]. In our study, iatrogenic neuropathies after humeral shaft osteosynthesis with blocking screws developed in 2.9% of patients. In 30% of cases, radial nerve injury was associated with distal screw blocking [9].

In this particular case, the injury resulted from a combination of several technical errors during the osteosynthesis procedure. Firstly, a screw of insufficient length was selected. On postoperative X-rays, it can be observed that, even with the proximal end of the screw protruding a few millimeters above the head of the humerus, there is a deficit of approximately 2 cm in length. Secondly, despite the presence of a hole for distal blocking in the sagittal plane, both blocking screws were inserted from the outside towards the inside. With the screw being too short, such blocking inevitably occurs over the radial nerve [10]. When soft tissue protection is inadequate, the nerve trunk is highly susceptible to damage during drilling or screw insertion. In some cases, damage caused by the drill's cutting edge leads to a complete nerve disruption, which, evidently, happened in this case.

Timely diagnosis of iatrogenic nerve injuries is crucial. Clinically identifying traumatic neuropathy after anesthesia has worn off is usually straightforward. However, the clinical approach does not provide insight into the nature of the injury since any nerve injury, from contusion to complete anatomical disruption, presents with a comprehensive picture of sensory-motor deficit.

Visualization of the radial nerve through ultrasound examination allows for accurate determination of the level and nature of the injury [1, 3, 6, 7]. Conducting the examination immediately after surgery and confirming nerve trunk disruption would allow for immediate repair of the nerve integrity. In cases of diagnosed complete anatomical disruptions, we perform a revision with nerve integrity restoration. If conflicts with fragments or metal constructs are identified instrumentally in the context of radial nerve neuropathy, we conduct revision and neurolysis. In cases with inconclusive results from instrumental examinations, we perform nerve revision. An active-waiting strategy, in combination with conservative treatment, is chosen when the anatomical disruption or conflicts with metal constructs are not confirmed instrumentally. In the absence of positive progress from conservative treatment within 3-4 months, we perform a nerve revision. Unjustified delay in the results of conservative treatment without verification of the type of nerve injury jeopardizes the possibility of restoring lost upper limb function [1, 2].

In this clinical case, after humeral shaft osteosynthesis, with the clinical symptoms of radial nerve injury in the early postoperative period, the lack of medical vigilance and failure to conduct timely diagnostic verification led to the absence of instrumental diagnosis, which resulted in the late determination of the nerve injury's nature. The patient's initial consultation at our clinic occurred three months after the iatrogenic complication. The absence of clinical improvement and the detected nerve conduction block according to the ENMG data provided the basis for searching for the anatomical cause of the persistent functional impairment. Visualization examination revealed nerve disruption.

The degree of motor function recovery in the upper limb muscles directly depends on the timing of surgical treatment and patient rehabilitation. ENMG data shows that muscle contractility impairment in the form of fibrillation potentials manifests itself within 3 weeks after nerve injury, and motor function inhibition becomes irreversible in the 12-18 month period. Muscle degeneration becomes irreversible within 18-24 months [1]. Literature reports observations confirming that operative treatment performed six months after injury results in significantly poorer nerve recovery [5]. After 10-12 months, the only option for restoring wrist and finger extension function is tendon transposition [1]. The best results have been described after neurolysis, nerve suturing, and grafting using short autografts within 1-2 months [7, 11, 12].

Postoperative treatment is also essential for the quality and timing of limb function recovery. The goal of influencing the damaged nerve is to create conditions for its physiological regeneration [10, 12].

The therapeutic approach aims to accomplish the following tasks:

Restoration of tissue trophism (combatting edema and hypoxia through physiotherapeutic treatment, antihypoxants, and medications improving microcirculation).

Restoration of nerve structure and function (activation of axoplasm movement, maintenance of conditions for axon and myelin regeneration, improvement of nerve impulse conduction and neuromuscular transmission). For this purpose, B-group vitamins, cholinesterase inhibitors, and phospholipid donors are used.

Prevention of atrophy in immobilized and denervated limb tissues (prophylaxis against joint contractures, denervated tissue training). Physiotherapy and myostimulation play a crucial role in this aspect.

We believe that the comprehensive postoperative rehabilitation treatment, which includes medication therapy, therapeutic exercises, and physiotherapy, including electromyostimulation, allowed us to achieve excellent functional results.

CONCLUSION

Iatrogenic radial nerve injury is a common complication of operative treatment for humeral shaft fractures, particularly with screw blocking. A significant portion of such complications is related to nerve injury during distal blocking. Surgical prevention of such complications involves appropriate selection of the fixator and adhering to the technique of inserting blocking screws outside the area of the radial nerve.

Delayed completion of comprehensive examination and lack of early operative treatment in patients with radial nerve injuries lead to the absence of full functional recovery, potential muscle atrophy, and inhibition of motor function. Operative treatment aimed at restoring the radial nerve in the early stages after injury, combined with a full spectrum of postoperative rehabilitation over the course of a year, is the only correct treatment approach. The timing of specialized care for patients with radial nerve injuries plays a significant role in the restoration of upper limb function and the patient's workability.

DISCLAIMERS

Author contribution

Kisel D.A. — patient treatment, data analysis and interpretation, writing and drafting the article.

Fain A.M. — data analysis and interpretation, drafting the article.

Svetlov K.V. — data analysis and interpretation, drafting the article.

Bogolyubsky Yu.A. — data analysis and interpretation, writing the article.

Aleynikova I.B. — data analysis and interpretation, writing the article.

Sinkin M.V. — data analysis and interpretation, drafting the article.

All authors have read and approved the final version of the manuscript of the article. All authors agree to bear responsibility for all aspects of the study to ensure proper consideration and resolution of all possible issues related to the correctness and reliability of any part of the work.

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