Clinical case
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Multidisciplinary approach to repair of intra-articular fractures of the distal radius in a complicated setting (prehabilitation)

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Abstract

Introduction Treatment of malunited periarticular fracture of the distal metaepiphysis of the radius in a complicated setting is challenging and involved orthopaedic care and related specialties of neurologists, neurosurgeons and rehabilitation specialists. New methods are offered for repair of the distal radius fractures but the results obtained to date cannot be considered satisfactory, since the treatment is aimed at the restoration of the anatomical relationships and the hand function.

The **objective** was to demonstrate the role of prehabilitation preparing patients for elective reconstructive surgery, to present a multidisciplinary approach to the treatment of malunited radius fracture complicated by posttraumatic compression ischemic multineuropathy.

Material and methods The medical history of a 56-year-old patient with distal radius malunion complicated by posttraumatic compression ischemic multineuropathy was reviewed. Outcome criteria included absence of complaints and restored function of the hand and the wrist.

Results A positive functional outcome was recorded after prehabilitation and surgery. Early postop, the DASH scored 35, palmar flexion measured 64° with dorsiflexion of 61° and dynamometry of 30 kg seen with the left involved hand. A faster recovery of the hand function occurred due to regression of neurological disorders.

Discussion Treatment of the distal radius malunion in a complicated setting suggests the involvement of related specialists including neurologists, neurosurgeons, professionals in functional and diagnostic radiology, rehabilitation specialists so that the approach must be multidisciplinary. A preoperative course of prehabilitation supervised by a neurologist and a rehabilitation specialist is essential for the patient to achieve a higher basic level of functionality. Surgical treatment must be a stage of multi-stage multidisciplinary treatment of distal radius malunion in a complicated setting.

Conclusion The clinical case showed an effective multidisciplinary approach in the treatment of distal radius malunion in a complicated setting. Preoperative preparation (prehabilitation) had a positive effect on the postoperative recovery and functional results.

Keywords: radius malunion, compression ischemic multineuropathy, prehabilitation

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INTRODUCTION

The upper limb sustains a wide variety of fractures [1–7]. The upper limbs have been in the process of evolutionary change developing specific professional skills of a modern human with an effect on working capacity and life support. Since the early 19th century, the collection of knowledge respective to fractures of the distal radius has expanded exponentially. This is confirmed by the famous statement of Guillaume Dupuytren: "This fracture is so common, the results are so poor, that one should not be surprised at such a great interest that I personally and my contemporaries show in relation to the fracture of the distal radius" [8]. Despite obvious advances in medicine, the treatment of the cohort of patients is of relevance. There is an increase in the number of patients suffering injuries to the distal metaepiphysis of the radius that constitute 11.6 to 36.3 % of all fractures of the locomotor apparatus [9–14]. Distal radius fractures account for 18 % in elderly patients [15, 16]. Although children and the elderly are at greater risk for the injury, distal radius fractures occur in individuals of working age. With the low incidence of the fractures, complications can lead to long-term disability in younger healthy people. In a 30-year follow-up study of young adults in Sweden with distal radius fractures, the authors found that of the 28 % of study participants who had extra-articular fractures (average age of 31 at time of fracture, range 18–40), only 37 % had even minor complaints of pain, decreased mobility [16]. The social significance of the problem is due to frequent complications (on average about 30 %, as reported by many authors) after inadequate surgical treatment and physical rehabilitation and high rates of poor functional results [17]. Most patients recover and regain function, but almost a fifth have residual symptoms including pain, neurological symptoms and disability after one year [18, 19]. Malunion is the main cause of residual symptoms and occurs in approximately 5 % of fractures [20]. Any malunion that results in discrepancy at the distal wrist joint can cause pain on the ulnar side of the joint and reduce rotation of the forearm bones. Patients may suffer from decreased grip strength, decreased hand and forearm function and cosmetic impairment [19]. Although most patients regain satisfactory wrist function, 23–31 % of distal radius fractures cause permanent limitation of function due to pain, lost range of motion and grip strength [21, 22]. Although malunion is recognized as a relative indication for surgery, corrective surgery may be challenging and fail to restore a "normal" wrist even with careful preoperative planning [21, 23, 24]. Complications arising after corrective osteotomy account for 18.2 % [25]. Candidates for surgery should be patients with persistent pain and dysfunction associated with inconsistency of the articular surfaces of the distal wrist joint [23, 26]. The timing of the operation should be carefully considered. A targeted physical therapy program for the wrist stretching and strengthening should be the first-line treatment for functional limitations [23]. A complete neurological examination is intended to rule out carpal tunnel syndrome, which occurs in 17 % of patients, and signs of complex regional pain syndrome [26]. Consultations with specialists of related specialties are essential in the treatment of patients in the cohort if we are guided by the principle that surgery should be the last argument: "Ultima ratio". Prehabilitation is a relatively new direction including individual preparation of patients for the upcoming operation "A major operation, just like a marathon, requires preparation" [27]. To date, protocols have been developed for the prehabilitation of patients who are planning to undergo large joint replacement [28, 29, 30]. In our opinion, a similar practice can be applied to patients with radius malunions in a complicated setting. Moreover, these are not urgent operations placing the patient at risk by postponing the procedure. Comparative studies of early fixation of distal radius fractures and delayed corrective osteotomy showed that the results of corrective osteotomy are not inferior to the results of early internal fixation [31]. Most authors agree that patients with persistent symptoms should be recruited only six months after injury [23]. Some authors [32] report improved postoperative scores with a shorter interval between injury and corrective osteotomy. Over the past 100 years, new techniques have been offered for distal radius fractures and, despite this, the results obtained to date cannot be considered satisfactory. Treatment of distal radius fractures remains a challenging problem. The purpose of the work was to demonstrate the importance of prehabilitation

during the period of preparing patients for planned reconstructive operations, to present the result of a multidisciplinary approach in the treatment of a patient with an improperly healed fracture of the radius, complicated by post-traumatic compression-ischemic multineuropathy.

The objective was to demonstrate the role of prehabilitation preparing patients for elective reconstructive surgery, to present a multidisciplinary approach to the treatment of malunited radius fracture complicated by posttraumatic compression ischemic multineuropathy.

MATERIAL AND METHODS

The study included a medical history of a patient with a distal radius malunion in a complicated setting.

A 56-year-old patient R. sustained an injury to her left upper limb as a result of a fall on May 25, 2022 and was diagnosed with a closed comminuted intra-articular extension fracture of the distal metaepiphysis of the radius graded as AO 23-C1, Fernandez III (Fig. 1).

Fig. 1 Preoperative radiograph of the bones of the hand and forearm bones of patient R. taken in the emergency room

A closed reduction of the forearm bones was performed under local anesthesia after examination. The limb was fixed with a circular plaster cast for 4 weeks. With the plaster cast removed, contact dermatitis and impaired sensitivity in the left hand were revealed. Neuromyography was performed and consultation with a neurologist arranged. Polyneuropathy of the left upper limb was detected. Conservative treatment, exercise therapy were administered by the neurologist. The patient was admitted to the North-Western Regional Scientific and Clinical Center named after. L.G. Sokolov (NWRSCC) after 5 months (October 31, 2022) due to weak positive dynamics and dissatisfaction with the results of treatment.

Outcome criteria included positive dynamics in the clinical manifestations, restored hand function.

A multidisciplinary approach was used preoperatively.

RESULTS

Upon admission, the patient presented with swelling of the left hand and lower third of the left forearm; limited movements in the interphalangeal joints of the hand with flexion of 45°, extension of 0° and in the wrist joint with flexion of 35° and extension od 60°. The patient experienced numbness on the lateral surface of the lower third of the left forearm, in the V, IV, III fingers of the left hand; a feeling of tension spreading on the lateral surface of the left shoulder and the forearm. The patient was diagnosed with malunited intra-articular comminuted fracture of the left radius graded AO 23-C1, Fernandez III; 5 mm radius shortening; dorsal angular displacement 30° (Fig. 2), osteoporosis and polyneuropathy of the left upper limb. Concomitant diseases indluded stage 3 hypertension, type 2 diabetes; contact dermatitis; grade 1 obesity.

The disability of the upper limb measured with the DASH questionnaire scored 68, VAS pain syndrome scored 6, hand grip strength was 37 kg on the right side and 22 kg on the left. Thickening of the lig. collaterale carpi ulnare and ultrasound signs of edema with a possible indirect external effect on the trunk of the left ulnar nerve were detected with ultrasound dopplerography.

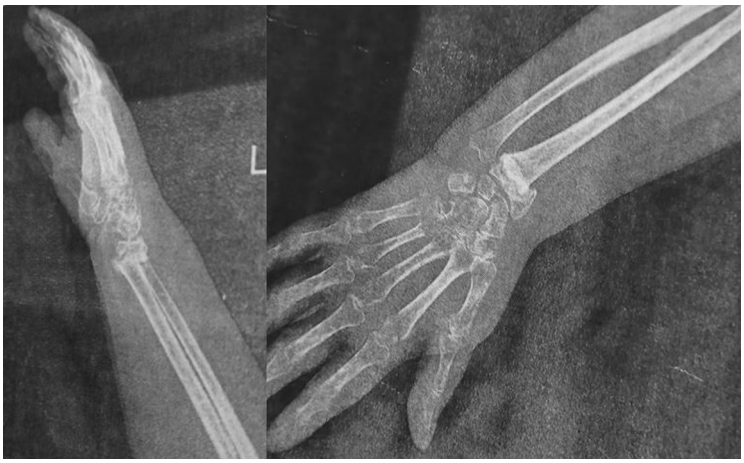

Fig. 2 Radiographs of the wrist joint of patient R. produced on admission to the hospital

ENMG of 01.11.22 showed moderate neuropathy of the median nerve at the level of the carpal tunnel on the left with moderate dysfunction of sensory fibers and mild dysfunction of motor fibers. The injury indicated mixed, mild axonal-demyelinating lesion of the superficial radial nerve on the left, moderate axonal lesion of the distal sensory fibers of the nerves of the upper extremities of the PSP type. There were no signs of damage to the ulnar nerve or motor fibers of the radial nerve.

The patient was examined by a neurologist and diagnosed with post-traumatic compression-ischemic multineuropathy of the median and superficial radial nerves on the left with mild motor and sensory impairment; axonal distal sensory polyneuropathy of the upper extremities. Recommended: intravenous infusion of saline solution with thiogamma, trental No. 10; intramuscular injections of milgamma and neuromidin No. 10; tablet drug Tebantin 300 mg Day 1, 1 tablet at night, increasing to 1 tablet 3 times a day if needed.

A decision on surgical treatment with corrective osteotomy and bone grafting was associated with such factors as regional osteopenia of the distal radius diagnosed by radiography, the absence of severe pain and the presence of contact dermatitis at the site of surgery. Conservative treatment included infusion therapy to improve microcirculation and reduce edema, vitamin therapy, a course of physical therapy and exercise therapy. The patient was discharged from the hospital at two weeks to continue treatment as an outpatient.

A prehabilitation course with the participation of neurologists, rehabilitation specialists and physical therapists was recommended. Medication prescribed included 100 mcg of calcitonin per day, 1000 mg of elemental calcium in the form of calcium carbonate and 400 IU (10 mcg) of vitamin D3 for 12 weeks; physiotherapy, classes with a rehabilitation specialist to achieve a satisfactory range of motion in the wrist joint, bone strength and improve radiological signs of regional osteopenia. The patient was re-hospitalized 6 months later to undergo corrective osteotomy. Physical examination showed improved condition of the soft tissues, no swelling, no symptoms of contact dermatitis. Numbness in the 5th and 4th fingers of the left hand and deformity at the level of the left wrist joint persisted. Regional osteopenia of the distal radius, diagnosed radiographically at 6 months, decreased (Fig. 3).

Fig. 3 Radiographs of the wrist joint of patient R. showing no signs of osteopenia

Surgical treatment performed on June 16, 2023 included corrective osteotomy and bone grafting of the radius. A pre-curved plate with polyaxial screws was used to address angulation. The plate was first attached to the distal fragment and the stem of the plate was used as a joystick to translate and reduce the bone length allowing for a gentle and gradual realignment by stretching the soft tissue. Using the plate attached to the distal fragment as a joystick could be complicated by cutting through the screws or by a broken distal fragment, but the adverse event was prevented by a preoperative treatment of regional osteopenia of the distal radius (Fig. 4).

The wound healed by primary intention early post op with the radius realigned and reduced. The cosmetic defect was repaired (Fig. 5). Neurological disorders resolved shortly after surgery, movements in the fingers were within normal limits (Fig. 6).

Fig. 4 Postoperative radiographs of the hand and the forearm bones of patient R. showing fixation of the radius fracture

Fig. 5 Clinical outcome of surgery at one week

Fig. 6 Clinical outcome of surgery at 4 weeks

DISCUSSION

Distal radius fractures, like most periarticular and intraarticular fractures, are difficult to treat that require an individual approach in each case [9, 10]. With such fractures, it is necessary to take into account the degree of The extent of bone displacement, their number, relationship to the articular surface and timing are essential [6]. Distal radius fractures can be treated conservatively or surgically [7]. The surgical treatment has become more common [5, 13]. Patients who are surgically treated in the irst hours after injury prior to swelling have more favorable conditions for wound healing, a shorter rehabilitation period and recovery timing. A fracture pattern and the surgical strategy play a role in the scenario [2]. Comminuted intra-articular fractures with displaced bone at the site of the wrist joint are technically difficult for adequate reduction and stable fixation. External fixation devices can be used in such cases relying on ligamentotaxis [33]. A satisfactory reduction of intra-articular bone fragments can be associated with failure in fracture healing due to excessive distraction between the distal and proximal fragments of the radius. The risk of post-immobilization osteoporosis can cause difficulties with bone grafting of the radius nonunion in elderly patients and conservative treatment can be an option for the reasons with use adaptive capabilities of the body [6, 15]. The large group of patients with distal radius malunions can suffer accompanying conditions including neurodystrophic, tunnel syndromes, neurological disorders [10, 26]. The outcomes of the patients are often poor. The existing opportunities for the rehabilitation of such cases have not been realized. There is no continuity in observation and further treatment of the patients. This can lead to contractures and stiffness in the hand joints and persistent neurological disorders. New, more effective approaches to the treatment of patients with malunited intra-articular fractures of the distal radius with a complicated course are essential to reduce the rate of poor outcomes. Corrective osteotomy and bone grafting are used for the majority of patients. The overall incidence of complications after corrective osteotomy of the radius varies from 27 to 57 % even after surgical treatment [23]. Nonunions occur in 10.5 % of cases [34], delayed consolidation in 5.6 % of cases [35]. A high incidence of neuropathy and carpal tunnel syndrome are reported in patients with volar plate fixation [36]. Assessment of the functional and radiological outcomes after corrective osteotomy shows 18.2 % complications at five years [25].

At 5 months of the injury, the patient reported was diagnosed with post-traumatic compression-ischemic multineuropathy of the median and superficial radial nerve on the left with mild motor and sensory impairments, persisting post-immobilization osteoporosis of the distal radius, and other associated complications in the form of contact dermatitis at the site of the proposed surgical intervention. Surgical treatment in the condition was considered inappropriate. The management included prehabilitation, intensive neurological treatment, vascular infusion therapy, improvement of microcirculation of soft tissues and active exercising with rehabilitation specialists and physical trainers. The patient was re-admitted to the hospital with positive dynamics at 6 months of conservative treatment. Physical examination showed improved soft tissues, no swelling, no symptoms of contact dermatitis. Movements in the interphalangeal joints were within normal limits. Numbness persisted in the 5th and 4th fingers of the left hand. The signs of osteoporosis were radiologically reduced. Therefore, the physical condition facilitated a surgical option. A positive functional result was achieved within a relatively short period of time after prehabilitation and surgery. Early post op, the DASH scored 35, palmar flexion was 64°, dorsiflexion was 61°, hand grip strength on the left side was 30 kg. There was a faster recovery of hand function as a result of regression of neurological disorders., we have not found a description and evaluation of a multidisciplinary approach in the literature reporting patients with malunited fractures of the distal radius with a complicated course.

No prehabilitation protocol in the treatment of this cohort of patients have been described. Rehabilitation of patients with periarticular and intra-articular fractures is challenging. The complexity and responsibility in treating such patients increases many times over when we address the upper limb conditions due to the functional role. The treatment of malunited periarticular fracture of the distal metaepiphysis of the radius is more difficult with associated neurological disorders, stiff joints of the fingers and limited movements in the wrist joints. The treatment strategy for patients with malunited fractures of the distal radius with a complicated setting requires a multidisciplinary approach. The maximum treatment effect can be achieved through the concept of prehabilitation with involvement of several specialists.

CONCLUSIOPN

The case report of a patient with malunited fracture of the distal radius in a complicated setting has demonstrated the advantages of a multidisciplinary approach and the possibilities of prehabilitation in this cohort of patients.

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REFERENCES

1. Gumanenko EK, Khromov AA, Linnik SA, et al. New technologies in treatment of fractures of the upper extremities in patients with severe multiple and polytrauma. *Grekov's Bulletin of Surgery*. 2016;175(5):46-51. (In Russ.) doi: 10.24884/0042-4625-2016-175-5-46-51
2. Zubi Yu.Kh, Abujazar UM, Kilybaev AK, et al. Treatment outcome of forearm bones fractures. *Vestnik KazNMU*. 2015;(4):153-156. (In Russ.)
3. Aspenberg P, Sandberg O. Distal radial fractures heal by direct woven bone formation. Acta Orthop. 2013;84(3):297-300. doi: 10.3109/17453674.2013.792769
4. Jakubietz RG, Gruenert JG, Kloss DF, et al. A randomised clinical study comparing palmar and dorsal fixed-angle plates for the internal fixation of AO C-type fractures of the distal radius in the elderly. *J Hand Surg Eur Vol*. 2008;33(5):600-604. doi: 10.1177/1753193408094706
5. Karimi Nasab MH, Shayesteh Azar M, Fazel Moghaddam S, Taghipour M. Success Rate and Complications of Comminuted Intra-Articular Distal Radius Fracture Treatment via Closed Reduction and Use of a Mini-External Fixator. *Trauma Mon*. 2015;20(4):e18885. doi: 10.5812/traumamon.18885
6. Malets V. L., Volotovsky A.I. Results of surgical treatment of posttraumatic deformities of the distal metaepiphysis of the radius using bone autoplasty and decompression of the distal metaepiphysis of the radius. *Military medicine*. 2019;(4):21-25. (In Russ.)
7. Anzarut A, Johnson JA, Rowe BH, et al. Radiologic and patient-reported functional outcomes in an elderly cohort with conservatively treated distal radius fractures. *J Hand Surg Am*. 2004;29(6):1121-1127. doi: 10.1016/j.jhsa.2004.07.002
8. Dupuytren's M. Leçons Orales de Clinique Chirurgicale, faites à l'Hôtel Dieu de Paris. *Med Chir Rev*. 1834;21(42):289-330.
9. Melnikov VS, Korshunov VF. Methods of surgical treatment of improperly fused fractures of the distal epimetaphysis of the radius. *The journal of general medicine*. 2008;(3):78-84. (In Russ.)
10. Semenkin OM, Izmalkov SN, Golubtsov VI. Correcting osteotomy for intra-articular malunion of the distal radius. *Traumatology and orthopedics of Russia*. 2015;21(2):16-23. (In Russ.)
11. Volotovsky AI. Adaptive collapse of the wrist: notion, classification, modern methods of diagnostics. *Medical journal*. 2012;(3):26-31. (In Russ.)
12. Gilev MV. Surgical management of intra-articular impression distal radius fracture. *Genij Ortopedii*. 2018;24(2):134-141. doi: 10.18019/1028-4427-2018-24-2-134-141
13. Shershneva OG, Varentsov DS, Kryukova AS, et al. Operative and conservative methods of treatment of fractures of the distal metaepiphysis of the radius. *Young Scientist*. 2019;(23):179-183. (In Russ.)

14. Matveev RP, Bragina SV, Shneiveis AM. Differentiated approach to repair of displaced distal radial metaepiphyseal fractures. *Genij Ortopedii*. 2017; 23 (4): 396-400. doi: 10.18019/1028-4427-2017-23-4-396-400
15. Huetteman HE, Zhong L, Chung KC. Cost of Surgical Treatment for Distal Radius Fractures and the Implications of Episode-Based Bundled Payments. *J Hand Surg Am*. 2018;43(8):720-730. doi: 10.1016/j.jhsa.2018.05.007
16. Nellans KW, Kowalski E, Chung KC. The epidemiology of distal radius fractures. *Hand Clin*. 2012;28(2):113-125. doi: 10.1016/j.hcl.2012.02.001
17. Panova G, Panov N, Panova B, et al. Epidemiology of distal radius fracture. *III Congress of general medicine doctors of R. Macedonia with international participation, April 26-29, 2012*. Ohrid. URI: https://eprints.ugd.edu.mk/id/eprint/5390
18. Abramo A, Tagil M, Geijer M, Kopylov P. Osteotomy of dorsally displaced malunited fractures of the distal radius: no loss of radiographic correction during healing with a minimally invasive fixation technique and an injectable bone substitute. *Acta Orthop*. 2008;79(2):262-268. doi: 10.1080/17453670710015085
19. MacDermid JC, Roth JH, Richards RS. Pain and disability reported in the year following a distal radius fracture: a cohort study. *BMC Musculoskelet Disord*. 2003;4:24. doi: 10.1186/1471-2474-4-24
20. Cooney WP 3rd, Dobyns JH, Linscheid RL. Complications of Colles' fractures. *J Bone Joint Surg Am*. 1980;62(4):613-619.
21. Abramo A, Tagil M, Geijer M, Kopylov P. Osteotomy of dorsally displaced malunited fractures of the distal radius: no loss of radiographic correction during healing with a minimally invasive fixation technique and an injectable bone substitute. *Acta Orthop*. 2008;79(2):262-268. doi: 10.1080/17453670710015085
22. McQueen MM, Wakefield A. Distal radial osteotomy for malunion using non-bridging external fixation: good results in 23 patients. *Acta Orthop*. 2008;79(3):390-395. doi: 10.1080/17453670710015300
23. Haines SC, Bott A. Current Concepts: Corrective Osteotomy for Extra-Articular Deformity Following a Distal Radius Fracture. *Cureus*. 2023;15(10):e47019. doi: 10.7759/cureus.47019
24. Flinkkilä T, Raatikainen T, Kaarela O, Hämäläinen M. Corrective osteotomy for malunion of the distal radius. *Arch Orthop Trauma Surg*. 2000;120(1-2):23-26. doi: 10.1007/pl00021237
25. Cibula Z, Hrubina M, Melišík M, et al. Osteotomy after Distal Radius Fractures - Five-Year Clinical and Radiological Outcomes. *Acta Chir Orthop Traumatol Cech*. 2018;85(4):254-260. (In Slovak.)
26. Gaspar MP, Kho JY, Kane PM, et al. Orthogonal Plate Fixation With Corrective Osteotomy for Treatment of Distal Radius Fracture Malunion. *J Hand Surg Am*. 2017;42(1):e1-e10. doi: 10.1016/j.jhsa.2016.10.012
27. Wynter-Blyth V, Moorthy K. Prehabilitation: preparing patients for surgery. *BMJ*. 2017;358:j3702. doi: 10.1136/bmj.j3702
28. Swank AM, Kachelman JB, Bibeau W, et al. Prehabilitation before total knee arthroplasty increases strength and function in older adults with severe osteoarthritis. *J Strength Cond Res*. 2011;25(2):318-325. doi: 10.1519/JSC.0b013e318202e431
29. Franz A, Queitsch FP, Behringer M, et al. Blood flow restriction training as a prehabilitation concept in total knee arthroplasty: A narrative review about current preoperative interventions and the potential impact of BFR. *Med Hypotheses*. 2018;110:53-59. doi: 10.1016/j.mehy.2017.10.029
30. Bikchurin NM, Takhavieva FV, Aidarov VI, Akishin EM. Prehabilitation in the prevention of injuries of musculoskeletal system. *Practical medicine*. 2017;(8):36-39. (In Russ.)
31. Gouk C, Bairstow M, Thomas M, et al. A comparison of early fixation of distal radius fractures versus late corrective osteotomy of distal radius malunion. *ANZ J Surg*. 2022;92(12):3319-3324. doi: 10.1111/ans.18122
32. Mahmoud M, El Shafie S, Kamal M. Correction of dorsally-malunited extra-articular distal radial fractures using volar locked plates without bone grafting. *J Bone Joint Surg Br*. 2012;94(8):1090-1096. doi: 10.1302/0301-620X.94B8.28646
33. Neverov VA, Khromov AA, Kravchenko IN, et al. Surgical treatment of patients with fractures of distal metaepiphysis of the radial bone. *Grekov's Bulletin of Surgery*. 2009; 168 (1): 66-70. (In Russ.)
34. Disseldorp DJ, Poeze M, Hannemann PF, Brink PR. Is Bone Grafting Necessary in the Treatment of Malunited Distal Radius Fractures? *J Wrist Surg*. 2015;4(3):207-213. doi: 10.1055/s-0035-1558831
35. Gradl G, Jupiter J, Pillukat T, et al. Corrective osteotomy of the distal radius following failed internal fixation. *Arch Orthop Trauma Surg*. 2013;133(8):1173-1179. doi: 10.1007/s00402-013-1779-5

36. Wei J, Yang TB, Luo W, et al. Complications following dorsal versus volar plate fixation of distal radius fracture: a meta-analysis. *J Int Med Res*. 2013;41(2):265-275. doi: 10.1177/0300060513476438

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