Original article

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Modification of proximal row carpectomy (PRC) technique for adaptive wrist collapse (pilot study)

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Abstract

Introduction Proximal carpal row resection has been used for many decades as a "salvage procedure" for progressive wrist collapse. Improving the technique of its implementation, as well as introducing various modifications of the technique into practice are an important area for achieving better results of surgical treatment.

The **purpose** of this work was to demonstrate aspects of the modified proximal row carpectomy (PRC) technique and the immediate results of its use.

Materials and methods Eight patients aged from 24 to 57 years (seven men and one woman) were treated with the modified PRC technique. Treatment results were assessed using an adapted QuickDASH questionnaire, a visual analogue scale (VAS), based on patient satisfaction and radiographic results.

Results The average duration of surgical intervention was (149.0 ± 35.5) minutes. In the postoperative period, six patients (75 %) underwent fixation with an Ilizarov apparatus, the rest with a plaster splint. The average range of motion of flexion and extension was (67.5 ± 18.3)°, range: 40–95°. The patients had an average of (35.6 ± 16.13)° extension, range: 10–65° and (31.87 ± 10.9)° flexion, range: 10–45°. Patients reported decreased grip strength after surgery. Pain syndrome according to VAS at rest was equal to 0–1 points and 3–4 points when the affected limb was loaded. Six patients completed the QuickDASH survey, with a mean score of (14.83 ± 4.25) points. All patients are satisfied with the result of treatment and the absence of pain at rest. Patients returned to their usual work.

Discussion Unlike the conventional dorsal approach through the III–IV tendon canals, the use of two mini-approaches provides a better cosmetic effect and makes it easier to restore the integrity of the tendon canals, which are important for the prevention of desmogenic contractures. The use of the Ilizarov apparatus has proven to be the method of choice, providing absolute stability and reduction of pain in the postoperative period. For patients under 45 years of age with increased functional demands, a balanced approach is required when choosing PRC or intercarpal arthrodesis, depending on which functional parameters are more important to the patient.

Conclusion The analysis of short-term results of using the modified PRC technique shows that it reduces the invasiveness of the operation, improves its esthetic result, provides pain relief and a satisfactory range of motion and grip strength.

Keywords: adaptive carpal collapse (ACC), Ilizarov apparatus, resection, proximal row of carpal bones

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INTRODUCTION

A pain-free and stable wrist joint is essential for full hand function. In clinical practice, patients frequently refer with pain at the wrist level, the causes of which are conventionally divided into mechanical, neurological and systemic [1]. The most common cause of chronic pain is osteoarthritis of the wrist, which is classified into inflammatory, degenerative, infectious and hemorrhagic [2]. Primary idiopathic osteoarthritis of the wrist (osteoarthritis) is a rare condition [3], while secondary osteoarthritis occurs after simple trauma, instability, dislocations, or inflammatory arthritis resulting from cerebral palsy, penetrating gunshot wounds [4], and infections [5].

Secondary degenerative arthritis of the wrist frequently results from injuries to the scapholunate ligament or fractures of the scaphoid followed by nonunion or malunion. Subsequently, adaptive collapse of the wrist may develop, a pathological condition consisting of a progressive disruption of the anatomically correct relative position of the bones and their fragments or rows of bones of the wrist, leading to a decrease in height, changes in biomechanics and a high rate of degenerative process. Wrist collapse should be considered as a unique outcome of instability, which has a long-standing nature that will aggravate the course of post-traumatic osteoarthritis [6].

One of the main tasks of a hand surgeon is to restore the anatomical and functional integrity of the damaged segment and relieve pain, and the surgeon has various types of surgical interventions for this purpose. The choice of treatment method depends on the cause and nature of the consequences of the causing pathology and the needs of the patient. Available procedures can be grouped into two main treatment options, namely partial or complete wrist arthrodesis [7–11] and wrist arthroplasty [12–16], as well as palliative and salvage treatments.

To relieve chronic carpal pain syndrome, decompression of the bone marrow cavity of the distal end of the radius is used [17], aimed at improving its blood supply, as well as partial or complete denervation of the wrist [18], which can be independent operations or complement others [19].

A common surgical technique for various degenerative conditions is resection of the proximal row of carpal bones. It refers to operations that preserve the range of motion (as opposed to total arthrodesis, when movement in the joint is sacrificed) [20]. Resection of the proximal row of carpal bones has several advantages: relative ease of execution, shorter duration of postoperative immobilization, and no risk of bone nonunion, unlike arthrodesis [21, 22]. It can be used in patients who do not require greater handgrip strength [23]. The consequence of the technique may be the process of osteoarthritis in the formed radiocapitate joint, which develops over time in most patients and is associated with heavy physical labor [24]. It may subsequently require additional surgical interventions. Despite that resection of the proximal row of carpal bones is time-tested, the problem of improving the technique of its implementation remains relevant [25]. It determined the purpose of our study.

The purpose of the work was to demonstrate aspects of the modified proximal row carpectomy (PRC) technique and short-term results of its use.

MATERIALS AND METHODS

Eight patients aged from 24 to 57 years were treated with the use of a modified technique for resection of the proximal row of carpal bones (Table 1), the average age was (37.75 ± 10.42) years.

Preoperative assessment was aimed at understanding the patient's degree of disability and is based on the patient's subjective assessment of pain and loss of function, as well as objective assessment of range of motion (goniometry) [26] and imaging data (radiography and CT).

Table 1

Preoperative clinical and demographic data

Patient	Age	Sex	Dominant hand	Affected hand	Indications	Range of motion (extension/axial alignment/flexion)	DASH	Pain at rest	Pain under loading
1	24	M	right	right	Aseptic necrosis of the lunate bone	30° / 0° / 10°	30	yes	yes
2	30	M	right	left	Transscaphoid perilunate dislocation	4° / 0° / 28°	–	yes	yes
3	40	F	right	right	SNAC stage 2	20° / 0° / 30°	71.6	yes	yes
4	37	M	right	left	Neglected perilunate dislocation	10° / 0° / 10°	–	yes	yes
5	57	M	right	right	SLAC stage 2	10° / 0° / 20°	47.5	yes	yes
6	47	M	left	left	Aseptic necrosis of the lunate bone	90° / 0° / 90°	–	yes	yes
7	36	M	right	left	Neglected perilunate dislocation	15° / 0° / 35°	–	yes	yes
8	31	M	right	left	SNAC stage 2	5° / 0° / 30°	–	yes	yes

All patients were admitted for planned treatment. Six patients (75 %) had a history of trauma. Indications for surgery were:

— chronic perilunate dislocation (*n* = 2; 25 %);

— transscaphoid perilunate dislocation (*n* = 1; 12.5 %);

— advanced collapse due to nonunion of the scaphoid fracture [SNAC stage 2] (*n* = 2; 25 %);

— scapholunate advanced collapse (SLAC stage 2) (*n* = 1; 12.5 %);

— signs of grade 4 aseptic necrosis of the lunate bone without a positive effect from conservative treatment (*n* = 2; 25 %).

All patients complained of aching pain at rest. The pain intensified with exercise and caused limited movement and decreased handgrip strength.

Treatment results were assessed based on the QuickDASH (Quick Diasabilities of the Arm, Shoulder and Hand) questionnaire [27], pain was evaluated with the Visual Analogue Scale (VAS), goniometric assessment of range of motion in the wrist joint, and hand grip strength score (0–1, 1–2, 2–3), where a score of "3" corresponded to the strength of a healthy contralateral hand.

Surgical technique

During the operation, conduction anesthesia was used. The patient's position was supine with the arm on the bedside counter. After preparing the surgical field, a hemostatic pneumatic tourniquet was applied at the level of the middle third of the humerus. Surgical approach to the scaphoid bone was carried out from a 4–5 cm long incision along the anterior surface of the forearm, using the flexor carpi radialis (FCR) as an external landmark. After making the incision, the tendon was moved to the side for exposure of the capsule of the wrist joint and for examination of the articular surfaces of the distal radius and scaphoid bones (Fig. 1). Next, resection of the scaphoid bone was performed. To prevent impingement syndrome, resection of the styloid process of the radius was performed. Then, through an additional dorsal approach 4–5 cm long, the retinaculum extensorum was exposed and the 5th canal of extensors was opened. The extensor tendons of the fifth finger were moved to the side, the wrist capsule was incised along the dorsal radiocarpal ligament (DRC) (Fig. 2), and the distal radius and midcarpal joint were examined to ensure the integrity of the lunate fossa of the radius and capitate bones.

If they are damaged, an alternative to surgery must be considered. If there is any question regarding the correct identification of the carpal bones, fluoroscopy with a metal wire marker is an option. Removal of the triquetral and lunate bones is performed similarly to the removal of the scaphoid using surgical techniques.

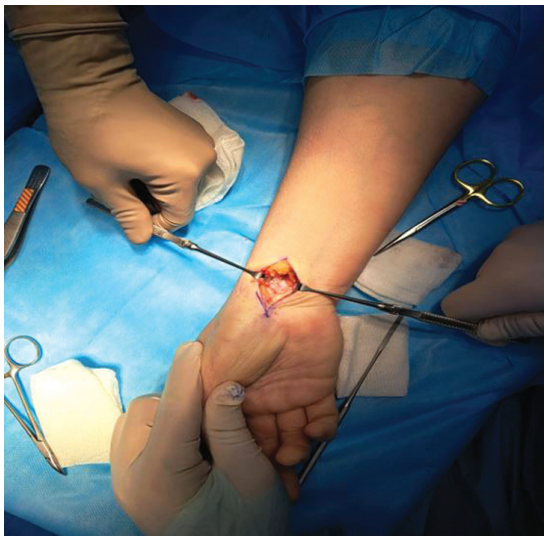

Fig. 1 Palmar approach

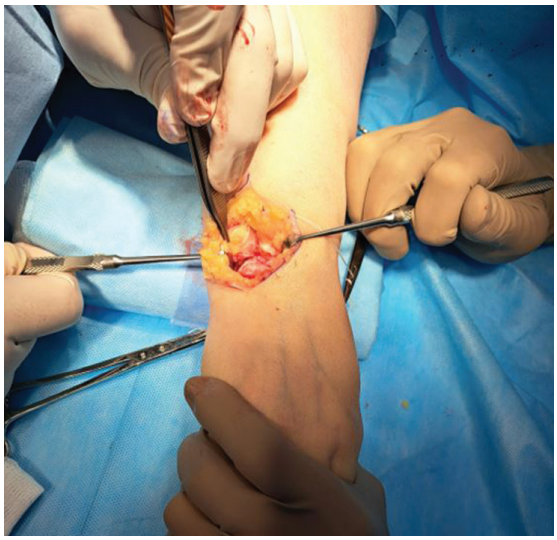

Fig. 2 Dorsal approach to the wrist

Then X-ray control was carried out. The joint capsule was sutured with non-absorbable suture material in accordance with literature recommendations [28]. After removing the tourniquet, thorough hemostasis was carried out and the wound was closed in layers with an interrupted or intradermal suture. In the case of perilunar dislocation and damage to the ligamentous apparatus, the wrist was immobilized in a functionally advantageous position using the Ilizarov apparatus. To do this, two wires were inserted crosswise in the lower third of the forearm and two wires were inserted in the middle third. The wires in the forearm were secured and tensioned in rings. The rings were connected to each other by straight rods. Two wires were drilled through the bases of the II–V metacarpal bones. The wires were fixed in a half ring. The half-ring and rings were connected by rods through hinges, providing a functionally advantageous position of the hand in relation to the forearm.

In the postoperative period, painkillers, dressings, antibiotic prophylaxis were prescribed; from the third day after the operation, exercise therapy was initiated.

RESULTS

Short-term results

The short-term results up to 1 year after removal of the device were monitored on an outpatient basis. At follow-ups, complaints were assessed, goniometry (Table 2), and radiography of the hand in two projections (direct and lateral) were performed to assess the condition of the radiocapitate joint.

A particular feature of the studied group of patients was their young age, mean 37.75 ± 10.42 years.

The average duration of surgery was (149.0 ± 35.51) minutes. In the postoperative period, six patients (75 %) underwent fixation with the Ilizarov apparatus, in the rest fixation with a plaster splint was used.

In the period from 3 months up to 1 year from the moment of surgery, the average volume of flexion and extension was (67.5 ± 18.3)°, range: 40–95°, of which (35.6 ± 16.13)° extension, range: 10–65°, and 31.8 ± 10.9° of flexion, range: 10–45°.

Table 2

Short-term results (up to 1 year)

Patient	Age	Sex	Dominant hand	Affected hand	Indications	Range of motion (extension/axial alignment/flexion)	Quick DASH	Pain at rest	Pain under loading
1	24	M	right	right	Aseptic necrosis of the lunate bone	10° / 0° / 30°	17.5	no	yes
2	30	M	right	left	Transscaphoid perilunate dislocation	30° / 0° / 45°	–	–	–
3	40	F	right	right	SNAC stage 2	45° / 0° / 45°	17.6	no	yes
4	37	M	right	left	Neglected perilunate dislocation	65° / 0° / 30°	13	no	no
5	57	M	right	right	SLAC stage 2	30° / 0° / 30°	7	no	no
6	47	M	left	left	Aseptic necrosis of the lunate bone	30° / 0° /3 0°	18	no	no
7	36	M	right	left	Neglected perilunate dislocation	30° / 0° / 35°	–	–	–
8	31	M	right	left	SNAC stage 2	45° / 0° / 10°	15.9	no	no

Pain according to VAS at rest was 0–1 points, and 3–4 points under loading of the affected limb. Six patients underwent a QuickDASH survey, the average score was (14.83 ± 4.25) points. The strength of the hand grip was 1–2 points.

All patients are satisfied with the result of treatment and the absence of pain at rest. The patients returned to their normal activities.

Case report

A 36-year old patient aged complained of pain at rest and during exercise, limited movement in the left hand. An. morbi: domestic injury on 23.10.2021, bruise from falling on the hand. Perilunar dislocation of the hand was diagnosed at his residence hospital. Under local anesthesia, the dislocation was reduced and the hand and wrist joint were immobilized with a plaster splint. The follow-up radiographs detected that the dislocation had not been eliminated. The patient fixed his hand with an orthosis for two months and underwent physiotherapy courses. Due to persisting complaints, he was hospitalized at the National Ilizarov Medical Research Center for Traumatology and Orthopaedics on 09.03.2022.

The examination revealed chronic transscaphoid perilunate dislocation of the left hand, arthrosis, synovitis of the left wrist joint, and a nonunion of a comminuted fracture of the styloid process of the left ulna (Fig. 3–4).

Fig. 3 Radiographs at admission

Fig. 4 Function before surgery

Soft tissue contracture prevented reduction of the dislocation. On March 18, 2022, resection of the proximal row of carpal bones was performed, as well as resection of a fragment of the styloid process of the left radius with fixation of the hand and forearm in the Ilizarov frame (Fig. 5).

In the postoperative period, the pain severity decreased compared to the preoperative period and, due to fixation with the Ilizarov apparatus, no repeated subluxations or dislocations were noted. On April 12, 2022 (27 days after the operation), the device was removed. Subsequently, fixation with an orthosis was indicated for one month.

1 year after the operation, the volume of flexion and extension was 95°, of which 65° extension and 30° flexion (Fig. 6, 7).

Fig. 5 AP and lateral radiographs taken on day 1 post-surgery

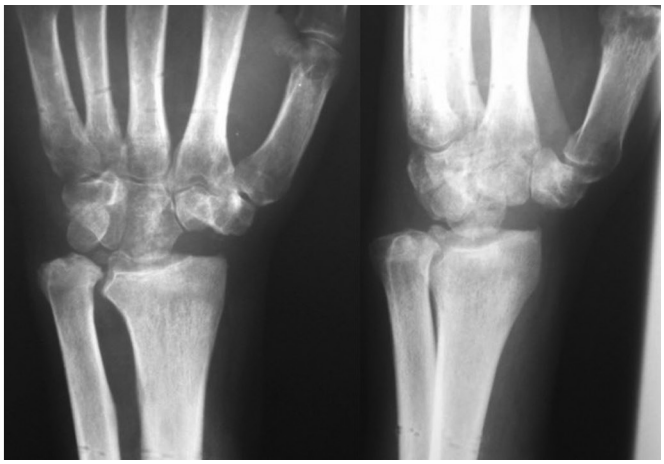

Fig. 6 Treatment result. AP and lateral radiographs at 1-year follow-up

Fig. 7 Photos of patient's hand function at 1-year follow-up

Pain score according to VAS at rest and under loading was zero. The QuickDASH score was 13 points. Hand grip strength was 2 points relative to a healthy hand.

DISCUSSION

According to literature sources, PRC has a wide range of indications [20]:

— scapholunate advanced collapse of the wrist [SLAC];

— advanced collapse due to scaphoid fracture nonunion [SNAC];

— Kienböck's disease with collapse of the wrist;

— chronic perilunate dislocation;

— osteonecrosis of the scaphoid bone (Preiser's disease or post-traumatic osteonecrosis);

— severe flexion contractures associated with systemic diseases (cerebral palsy or arthrogryposis).

Relative contraindications:

— lack of patient compliance;

— chronic compensated diseases of internal organs;

— skin diseases in the area of surgical intervention (in the acute stage): pyoderma, erysipelas;

— mental illnesses;

— young age, heavy physical work.

Absolute contraindications:

— chronic decompensated diseases of internal organs;

— mental illness of the patient;

— degenerative changes in the lunate fossa of the radius and capitate bone;

— inflammatory arthropathy (rheumatoid arthritis).

Progressive narrowing of the joint space and arthrosis of the radiocapitate joint inevitably occur after PRC due to replacement of the complex carpal joint with a hinge joint [24].

In patients under forty-five years of age with increased functional demands, a balanced approach is required when choosing PRC or quadrilateral arthrodesis, depending on which functional parameters (grip strength or range of motion) are more important to the patient [29].

Chim et Moran in a 2012-study analyzed long-term results of PRC in 147 patients and reported an average result of postoperative range of motion (flexion and extension: 73.5°) [24], which does not contradict our average results of range of motion, flexion and extension (67. 5 ± 18.3)°.

A special feature of our PRC technique is the presence of two mini-approaches. Unlike the conventional dorsal approach through the III–IV tendon canals, the use of two mini-approaches makes it easier to restore the integrity of the tendon canals and provides a better cosmetic effect, including by maintaining incisions along the Langer tension lines, which correspond to the natural orientation of the collagen fibers of the dermis. Such incisions usually heal better and cause less scarring [30], which is a significant factor in the prevention of desmogenic contractures. The use of the Ilizarov apparatus for chronic perilunar dislocations is also a new aspect of PRC modification, which has proven to be the technique of choice, providing high-quality immobilization of the wrist and reduction of pain in the postoperative period.

CONCLUSION

The analysis of the short-term results of the modified PRC technique shows that it reduces the invasiveness of the operation, improves the esthetic result, provides relief of pain at rest, a satisfactory range of motion and grip strength. The data obtained from eight patients treated are preliminary; further studies of short-term and long-term results will justify the introduction of the modified PRC technique into clinical practice.

Conflict of interest *The authors declare no conflict of interest.*

Source of funding *The authors received no funding for this work.*

Ethical statement *The studies were conducted in accordance with the ethical standards of the World Medical Association Declaration of Helsinki, Ethical Principles for Medical Research Involving Human Subjects, as amended 2000.*

Informed consent *All patients or their legal representatives signed informed consent for the publication of data obtained as a result of the studies, without personal identification.*

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