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Utilization of axillary brachial plexus block in the postoperative rehabilitation of intra-articular fractures of the distal humerus

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Objectives: An effective rehabilitation program is essential to prevent joint stiffness and regain range of motion after surgical treatment of intra-articular fractures of the distal humerus. We evaluated the effect of a physiotherapy program on functional results, that involved passive resistive stretching exercises performed under axillary brachial plexus block after radiographic observation of bone union of intra-articular fractures of the distal humerus treated with open reduction and internal fixation.

Methods: The study included 21 patients (7 females, 14 males; mean age 34±5 years; range 21 to 57 years) who underwent open reduction and internal fixation for intra-articular fractures of the distal humerus. All the patients had closed fractures. Six patients had AO type C1, six patients had C2, and nine patients had C3 fractures. Surgical treatment consisted of a posterior incision, olecranon osteotomy, and fixation of the metaphyseal fragments using two reconstruction plates placed medially and laterally. Active range of motion exercises were started on the third postoperative day. To prevent early development of heterotopic ossification, passive range of motion exercises were avoided. Active stretching exercises were initiated three weeks after surgery. Upon radiographic observation of bone union, axillary brachial plexus block was performed. The physiotherapy program involved passive stretching exercises during nerve block, and active weight exercises after recovery from motor block. The catheter remained in the axillary region for three months, during which functional rehabilitation was continued 2-3 times a week on an outpatient basis. Functional results were evaluated according to the criteria of Jupiter et al. after a mean follow-up period of 31 months (range 24 to 46 months).

Results: All fractures united within a mean of 11.9 weeks (range 9 to 17 weeks) except for one type C3 fracture. Functional results were excellent in 10 patients (47.6%), good in eight patients (38.1%), moderate in two patients (9.5%), and poor in one patient (4.8%). Two patients with a moderate outcome had associated multiple fractures in the ipsilateral extremity. Distribution of the functional results according to the type of fractures were 4 excellent, 2 good in type C1, 4 excellent, 2 good in C2, and 2 excellent, 4 good, 2 moderate, and 1 poor in C3 fractures. The mean loss of elbow extension was 16°. The mean elbow flexion, pronation, and supination were measured as 131°, 90°, and 75°, respectively. None of the patients had nonunion at the olecranon osteotomy site, superficial or deep infection, or heterotopic ossification. Three patients developed transient ulnar nerve neuropraxia that resolved spontaneously during the follow-up period. There were no complications related to axillary catheterization.

Conclusion: Following surgical treatment of intra-articular fractures of the distal humerus, a regular and pain-free physiotherapy program performed under axillary brachial plexus block on an outpatient basis increases patient compliance and enables early return to daily activities.

Key words: Anesthesia/therapeutic use; bone plates; brachial plexus; elbow joint/surgery; fracture fixation, internal/methods; humeral fractures/surgery; olecranon process/surgery; range of motion, articular.

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The treatment of intra-articular fractures of the distal humerus poses difficulty due to the complex anatomy of the elbow. The goal of surgical treatment is to obtain a functional elbow joint through anatomic restoration of the articular surface.[1,2] Currently, the treatment of intra-articular fractures of the distal humerus includes open reduction, rigid internal fixation, and early mobilization.[1,3] The results of treatment vary depending on the patient's age and anatomic type of the fracture.[4] Surgical treatment of intra-articular fractures of the distal humerus may be associated with complications including nonunion, malunion, vascular or nerve injuries, joint stiffness and instability, avascular necrosis, Volkmann's ischemic contracture, and heterotopic ossification.[1,3] Functional results worsen in parallel with the increase in the grading type of the fracture.[1,5-7] Thus, all these complications and adverse conditions will affect elbow functions. An effective rehabilitation program is essential after surgical treatment to maximize the mobility and functionality of the upper extremity.

Current treatment approaches aiming at early postoperative mobilization have resulted in improved functional results and decreases in complication rates.[1,3] However, six-week immobilization of the elbows required for union postoperatively still constitutes a problem for rehabilitation programs. Early rehabilitation exercises can be painful for the patients, preventing early mobilization. On the other hand, soft tissue stiffness may develop due to the immobilization period required for soft tissue healing and fracture union, which is associated with functional losses.

The aim of this study was to evaluate the effect of a physiotherapy program on functional results, that involved passive resistive stretching exercises performed under axillary brachial plexus block after radiographic observation of bone union of intra-articular fractures of the distal humerus treated with open reduction and internal fixation.

Patients and methods

The study included 21 patients (7 females, 14 males; mean age 34±5 years; range 21 to 57 years) whose distal humerus intra-articular fractures were treated by open reduction and internal fixation. All the patients had closed fractures. According to the AO classification, six patients had type C1, six patients had C2, and nine patients had C3 fractures (Fig. 1a, b). Associated injuries were multiple fractures in the ipsilateral extremity in two patients, and a tibial shaft fracture in one patient. None of the patients had ulnar nerve palsy preoperatively.

All the patients were operated on within the first 72 hours of injury under general anesthesia and tourniquet application, in the lateral decubitus or prone position. First, the ulnar nerve was explored via a posterior longitudinal approach. Then, a chevron osteotomy was performed to expose the articular surface of the distal humerus. Following temporary fixation of articular fragments by K-wires, metaphyseal fragments were anatomically reduced and fixed by two reconstruction plates placed medially and laterally (Fig. 1c, d). In one type C3 fracture, an autograft was harvested from the iliac crest. The olecranon osteotomy was fixed by a spongious screw and tension wire bands. The ulnar nerve was transposed anteriorly and the wound was closed. The elbow was immobilized in an active arm splint after surgery. For prophylaxis against heterotopic ossification, indomethacin was started with a daily dose of 75 mg.[8]

Active range of motion exercises were started on the third postoperative day. To prevent early development of heterotopic ossification, passive range of motion exercises were avoided. Transcutaneous electrical nerve stimulation was applied in patients with persistent pain. To relieve pain and decrease edema, active elbow, wrist, and hand exercises were performed with the arm in 45-degree elevation and classic massage was applied to improve circulation. Active stretching exercises were initiated three weeks after the operation. Upon observation of sufficient bone union on radiographs, axillary brachial plexus block was applied. During nerve block passive stretching exercises were applied, followed by active weight exercises to strengthen the muscles after recovery from motor block.

All the patients were informed on axillary brachial plexus block and written consent was obtained.

An 18 G intravenous cannula was inserted into a peripheral vein of the contralateral forearm, through which intravenous midazolam (0.05 mg/kg) was administered as premedication 10 minutes before the procedure and an infusion of Ringer's lactate was started. Standard monitoring was used throughout the procedure, including arterial blood pressure, electrocardiography, and pulse oximetry.

Fig. 1. (a, b) Anteroposterior and lateral radiographies of an intra-articular fracture of the distal humerus (AO type C2) in a 24-year-old male patient. **(c, d)** Postoperative roentgenographic results showing complete bone union of the fracture and olecranon osteotomy site after 32 months.

Axillary brachial plexus block was performed with the patient in the supine position, the shoulder in 90° abduction, and the hand placed under the head. Following disinfection and skin infiltration with 0.5 ml of 1% lidocaine, the axillary brachial plexus was identified using a nerve stimulator (Stimuplex, B. Braun Medical Inc., Melsungen, Germany), an insulated needle of the cannula, and a catheter set (Contiplex, B. Braun). The initial stimulation frequency was set at 2 Hz, and the intensity of stimulating current was set at 1 mA, which was gradually decreased to <0.5 mA after observation of each muscular twitch. In case of puncture of a blood vessel, the needle was retracted and directed to the nerve.

The introducer cannula was advanced just a few millimeters past the needle tip, and the tip of the catheter was advanced just outside the introducer cannula. Bupivacaine 0.5% was injected at a 30-40 ml volume slowly and intermittently through the catheter. Assessment of sensory and motor block was made at 5, 10, 15, 20, 25, and 30 minutes after the completion of the injection into each nerve and at every 30 minutes. Complications of axillary block were recorded. The catheter remained indwelling in the axillary region for six weeks and was replaced when needed. The patient was discharged on the same day of block. A new catheter was implanted within a mean of one month in patients having problems related to catheter placement.

Fig. 2. Functional results of the same patient in Fig 1 at the end of 32 months.

After physiotherapy, the patient's elbow was kept in flexion in a brace and was fixed in extension at night. Functional rehabilitation was continued 2-3 times a week on an outpatient basis for three months, after which the catheter was removed. Functional results were evaluated according to the criteria of Jupiter et al.[6] The mean follow-up period was 31 months (range 24 to 46 months).

Results

All fractures united within a mean of 11.9 weeks (range 9 to 17 weeks) except for one type C3 fracture. No wound infection was encountered. Functional results were excellent in 10 patients (47.6%), good in eight patients (38.1%), moderate in two patients (9.5%), and poor in one patient (4.8%). Two patients with associated multiple fractures in the ipsilateral extremity had a moderate outcome. Distribution of the functional results according to the type of fractures were as follows: type C1 fractures, 4 excellent, 2 good; type C2 fractures, 4 excellent, 2 good; type C3 fractures, 2 ex-

cellent, 4 good, 2 moderate, 1 poor. The mean loss of elbow extension was 16 degrees. The mean elbow flexion, pronation, and supination were measured as 131°, 90°, and 75°, respectively (Fig. 2).

None of the patients had nonunion at the olecranon osteotomy site, superficial or deep infection, or heterotopic ossification. Three patients developed transient ulnar nerve neuropraxia that resolved spontaneously during the follow-up period. There were no complications related to axillary catheterization.

Discussion

The management of intra-articular fractures of the distal humerus is challenging for both the surgeon and the patient. The treatment of these fractures involves anatomical restoration of the articular surface, a stable fixation, and early motion.[1,9]

Various surgical approaches have been defined for the treatment of intra-articular fractures of the distal humerus, the most popular being transolecranon approach, triceps splitting, triceps tongue, and triceps reflecting anconeus pedicle (TRAP) approaches.[10,11]

Olecranon osteotomy is a preferred technique by many surgeons for surgical exposure for the treatment of complex intra-articular fractures of the distal humerus. Posterior exposure of the distal humerus through an olecranon osteotomy provides a wide exposure of the articulation, in particular the anterior aspect of the articular surface, as well as providing an excellent exposure for plate insertion.[10]

Wilkinson and Stanley[12] compared the degree of visualization provided by the triceps splitting, triceps reflecting, and olecranon osteotomy approaches in a cadaveric study and found that the olecranon osteotomy approach provided a greater exposure of the distal humeral articular surface than the triceps splitting approach.

However, studies on olecranon osteotomy have reported several complications such as nonunion, intra-articular adhesions, and arthritis.[5,10,11,13] In our study, union of the olecranon osteotomy site was achieved in all the patients.

Pajarinen and Björkenheim[3] stated that the main reason for an inadequate postoperative outcome was limited range of motion, which might be observed even after an anatomic reconstruction of the distal humeral articular surface. Long-term immobilization was implicated as the most important factor causing stiffness of the elbow. On the other hand, early active mobilization requires a stable fixation of the fracture. Patient-related factors such as poor bone quality, age, and fracture type may also affect the immobilization period and rehabilitation program.[3-11,13] In addition, functional results worsen in parallel with increasing grade of the fracture.[1,5-7] In our study, all the patients had excellent or good results except for three patients with moderate results, who were older than 55 years and had type C3 fractures.

There is consensus worldwide that early active mobilization of the elbow is essential to obtain successful functional results. However, passive resistive exercises after the completion of bone union are painful and decreases patient compliance. Gupta and Khanchandani[14] noted that all the patients presenting with decreased range of motion were either older patients or had a poor postoperative physiotherapy program. In our study, we believed that our postoperative physiotherapy program under axillary brachial plexus block eliminated pain and enabled a comfortable and effective setting, leading to better functional results.

Functional results obtained in our study seem to be better compared to the results of previous studies using similar surgical techniques but conventional rehabilitation methods. Atalar et al.[15] treated intra-articular fractures of the distal humerus in 21 patients with the parallel-plate technique. They reported the mean postoperative elbow flexion, extension, and total range of motion as 118°, 28°, and 90°, respectively. According to the criteria of Jupiter et al., their results were excellent in seven patients, good in 11 patients, moderate in two patients, and poor in one patient. Özdemir et al.,[7] in a study of 34 patients, found the mean postoperative elbow flexion as 115°, and extension loss as 26°, and concluded that the best results were associated with the use of the posterior approach and double-plate osteosynthesis. In our study, the mean elbow flexion was 131° and the mean extension loss was 16°; functional results were excellent in 10 patients, good in eight patients, moderate in two patients, and poor in one patient.

Even though it is important to wait until completion of bone union, early active motion of the elbow joint is needed to restore the normal mobility of the upper extremity. Rigid fixation allows early mobili-

zation, which in turn helps minimize the formation of intra-articular adhesions and periarticular fibrosis that compromise functional results.[14,15] However, passive resistive exercises are also required to prevent restrictions in range of motion after completion of union. In the literature, active motion is recommended in the early postoperative period, passive motion is recommended after the sixth postoperative week,[15] whereas passive resistive exercises are recommended in the late term.[16,17] In this period, however, passive stretching exercises are usually deferred due to pain. Axillary block provides alleviation of pain and enables the patient to follow the physiotherapy program. Thus, physiotherapy procedures become easier for both the patient and the rehabilitation team.

Comparison of the results of relevant studies is quite difficult due to several factors, including the small number of sample groups and differences in the distribution of fracture types, follow-up periods, surgical methods, and postoperative treatment strategies. Our functional results seem to be better when compared with those of studies having similar patient groups. The main limitations of our study can be listed as the small numbers of patient subgroups corresponding to fracture types and the lack of a control group. Nevertheless, the use of axillary brachial plexus block via an indwelling catheter throughout the rehabilitation period represents a distinct feature of our study. This contributed to increased patient compliance and follow-up due to pain-free rehabilitation. There were no catheter-related complications throughout the placement of the catheter. Although axillary brachial plexus block is an invasive procedure, it is quite easy and safe when performed by experienced anesthesiologists and increases the success of rehabilitation. Another limitation of our study was that we did not compare the patients with respect to postoperative functional results before and after three months of axillary brachial plexus block. However, classic rehabilitation programs begin passive resistive stretching exercises after six postoperative weeks.[17,18] Therefore, a comparison would not be appropriate between the results before and after axillary block, as the rehabilitation process would not be completed even in classic rehabilitation applications.

In conclusion, following surgical treatment of intra-articular fractures of the distal humerus, a regular and pain-free physiotherapy program performed with axillary brachial plexus block via an indwelling catheter on an outpatient basis increases patient compliance and enables early return to daily activities without the need for hospitalization.

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