Fractures of the upper end of the humerus are relatively common. They are predominant in the female population (85%), age over 50 years, where the force that leads to fractures in 90% of cases is moderate. Multifragmentary (three-part and four-part) fracture of the upper end of humerus, treated nonoperatively, often leaves behind a significant disability.1,2,3,4,5

Indications for immediate installation of shoulder prosthesis are:

- dislocated, four-part fractures (rarely three-part)
- fractures complicated by luxation of the humeral head
- little chances for good fixation of fragments
- little chances for survival of the humeral head
- the time elapsed since injury (more than 14 days)
- patient’s age over 65 years.

For successful treatment it is important to have data on age, dominant hand, professional and family anamnesis, possible alcoholism, diabetes, steroid use, and their past activities.6,7,8,9

A successful result of the procedure is expected in people with good bone quality, adequate muscle strength, and especially a good motivation for treatment.

Attitude of the Department of Shoulder Surgery, Clinic for Orthopedic Surgery and Traumatology, Clinical Center of Serbia in Belgrade; is that most of the fractures of the upper end of humerus should be operated, except those with tolerable fragment dislocation or because of contraindications for other reasons (metabolic side effects, cardiac contraindications, neurological and neuromuscular diseases, surgery on the shoulder previously done, possibly present an infection).10,11,12,13

MATERIALS AND METHODS

From 1985 onwards, over 700 patients with fractures of the upper end of humerus were operated at Clinic for Orthopedic Surgery and Traumatology, of which over 180 were three-part and four-part fractures. About 30% of these patients had complicated luxational multi-part fractures. Apart from acute fractures, there were about 5% of chronic cases with pseudoarthrosis of proximal humerus or avascular necrosis of the humeral head.

In 64 patients, these fractures were treated with shoulder hemiarthroplasty, while in the others was used osteosynthesis with the wire-loop, "T" plate, "L" plate or combination of plate and wire.
In 1989, at the Department of shoulder surgery, shoulder hemiarthroplasty was conducted for the first time. Patients were immobilized postoperatively by Desault bandage, and the rehabilitation began between the third and fourth week outpatient. Functional results were not satisfactory. After 6th month of operation, the achieved active anteflexion ranged from 50° -100°.

By analysis of the results of our patients (the period from October 2003 - 2010, the rehabilitation of 34 patients with shoulder hemiarthroplasty was conducted), we found that for the functional recovery of shoulder, the mass of the fragment of a large tuberculum is very important. Namely, the massive large bump with supraspinatus annex on it, provides a better couple of forces and facilitates the elevation of the arm.

Based on past experience, we believe that the four conditions are important for achieving the maximal functional recovery of the operated shoulder:

1. The selection of an adequate model of the prosthesis
2. Proper positioning of the prosthesis
3. Quality fixation of a large tuberculum and rotator cuff reconstruction
4. Early rehabilitation with well-chosen kinesiotherapeutic protocol

The selection of an adequate model of the prosthesis:
There are three essential components of the prosthesis that need attention:

a) The Head of Prosthesis, where four sizes (40, 43, 46, 49 mm) meet the needs of our population
b) "Wing" on the prosthesis stem.
c) Prosthesis stem, in terms of thickness (ideally 9mm), length (ideally 16 mm) and shape. The opening at the top of the stem is necessary for wire infiltration during fixation of bone fragments to the prosthesis. If large and small bumps are not firmly fixed to the stem, early rehabilitation is impossible.

Proper positioning of the prosthesis:
Here are two important moments:

a) setting the prosthesis at proper height in order to establish anatomical relationship with glenoid
b) an adequate angle of retroversion of head of the prosthesis.

a) The precise setting of the prosthesis vertically, according to many authors, is very important. The prosthesis set too high reduces subacromial space and leads to the shoulder pain, and by many authors, is the cause of non coalescence and migration of large tuberculum, its resorption and limitation of motion with the occurrence of pain in the shoulder.

Boileau and Walch designed a special apparatus (the Aequalis fracture jig), which achieves an almost ideal height and retroversion of the head. This retroversion in the postoperative period usually becomes corrected spontaneously during rehabilitation (after 2-3 weeks), but if it is significant (more than 1/2 of the head), it can aggravate and slow down the rehabilitation.

b) The angle of retroversion varies from author to author, from 150 to 250. Many authors believe that a poor retroversion of the prosthesis causes the migration of large bump and poor functional outcome.

We noticed that the retroversion angle from 150 to 250 provides the best mobility of the shoulder.

**The anatomical reconstruction of large and small tuberculum**

We believe that a good adaptation and strong mutual fixation of both tuberculum, their fixation to the prosthesis stem and fixation of the large tuberculum to the diaphysis of the humerus- is extremely important for the healing quality of fragments. Pay particular attention to preserving the fragment mass of the large tuberculum, and if it is small, between the tuberculum and prosthesis stem place the spongy chips taken from the extirpated humeral head.

**Early rehabilitation with well-chosen kinesiotherapeutic protocol**

Rehabilitation of patients with shoulder hemiarthroplasty is essential for optimal recovery of functions!

Preoperatively, the patient must be familiar with the stages of post-operative rehabilitation.

At the end of 2003., a new approach of rehabilitation in surgery on the shoulder - early rehabilitation, was agreed. Until then, patients with shoulder hemiarthroplasty were sent home after the 6th day of operation, they were immobilized with triangle shawl, and a physical therapy began 3-4 weeks after the operation outpatient.

With the new approach, we begin the rehabilitation on the first postoperative day. We use a combination of rehabilitation protocols by Neer, and protocols from Johan Hopkins University in Baltimore. Based on gained experience, over time we’ve changed the established original system of exercises and modified the duration of individual stages of treatment, so that some periods are shortened, and the rehabilitation process is significantly accelerated. The protocol involves an individual approach depending on the quality of the applied surgical technique and the ability of patient to participate in the program.

We apply the exercises twice a day for 20-30 minutes. The operated patients remain hospitalized for about 4 weeks, depending on the progress of rehabilitation.

The protocol includes three phases:

1. The first phase aims to reduce pain and swelling, increase range of motion in the shoulder joint and provide protective positions training. This phase usually lasts until the end of the fourth postoperative week.

2. In addition to the specific exercises for the shoulder region, which include pendulous, passive, selfassisting and isometric exercises, we conduct active exercises for the elbow, hand and fingers.

   With pendulous exercises we speed muscle relaxation.
With passive exercises, the anteflexion of 90° is to be achieved by the end of the second postoperative week. We avoid external rotation.

Self-assisting exercises are performed with healthy hand or stick. Practicing the movements of the front elevation, external rotation, abduction and anteflexion. Exercises with the composed hands behind occipitus and elbows that synergistically move way back, activate the trapezoidal, rhomboid muscle, back head of deltoid muscle and spinal musculature. This is called a siesta position. Completely done siesta position means the recovery of the functional rotation and adequate elasticity of the front joint capsule.

Isometric exercises: of flexion, abduction, external and internal rotation in a lying, sitting and standing position we start after the second week. During the third week the exercise program is expanded with exercises with pulli-apparatus.

The second stage lasts from 5th -10th week and aims to reduce pain, increase active shoulder mobility and improve functional activities. At this stage we start with: active exercises, strength exercises and stretching exercises. All the exercises from previous phases are continued.

Third phase starts from week 11. We focus on increasing the muscle strength and improving the control of movement coordination in the shoulder, during activities of daily life.

We actively conduct this program for three months, and then follow the patient over the next nine months, during which time he performs these learned exercises at home. During the first 4 weeks in the hospital, it is the team work with daily cooperation with orthopedists (operator), physiatrists and therapists. The motivation of the patient is extremely important for successful treatment.

When patients leave the hospital, they proceed with the learned exercises at home. Any progress is monitored by a physiatrist and an orthopedic surgeon (operator). The follow-up time is 12 months. The results are evaluated using the Constant-score.

The kinesiotherapeutic protocol which we apply with shoulder hemiarthroplasty, represents a basic model of work with the patient and sometimes requires corrections, whether it is a slower progression of function recovery in question, or the certain postoperative complications when we work with a limited exercise program.

**RESULTS**

The results of this retrospective study in several orthopedic centers in France, organized by the French Orthopedic Society in 1995 in 188 patients with shoulder hemiarthroplasty with fractures, also speak in favor of the assertion that the results of this intervention are often poor and unpredictable. The average achieved active elevation in these patients was only 80º, with pain during movement in 30% of operated patients.

In the period from October 2003.-2010. at the Department of Shoulder Surgery Clinic for Orthopedic Surgery and Traumatology, Clinical Center of Serbia; the rehabili-

<table>
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<th>Table 1: Patients with shoulder hemiarthroplasty after 6 months of surgery treated with early rehabilitation</th>
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tation of 34 patients with shoulder hemiarthroplasty was conducted.

We achieved surprisingly good results. Patients were leaving the department after 4 weeks of continuous kinesiotherapeutic program scoring full painless or nearly full assisted (selfassisted) anteflexion.

Shoulder hemiarthroplasty was performed in following cases:

Neer-4 fr. 12
Neer-4 fr. + lux 8
Neer-3 (male sanata) 2
Neer-4 (male sanata) 4
Neer-2 (pseudoarthrosis) 3
Neer-4 (avascular necrosis) 5

The controls were made 3 months post surgery, 6 months post surgery and after one year. We studied active movements of anteflexion, abduction, external and internal rotation, presence of pain in movements and limb strength. Achieved active anteflexion and presence of pain were the main parameters for statistical evaluation. (Table 1)

Patients with shoulder hemiarthroplasty after 6 months of surgery treated with early rehabilitation.

The achieved results are accompanied by a precise evaluation of Constant score after sixth month of operation. It estimates pain by scoring system, the mobility of the shoulder joint, the functional evaluation of the hand and grip strength. In 25 patients (73.5%) Constant-score was > 90 points. In 7 patients (20.6%) was 80-89, and in 2 patients (5.9%) the value of Constant score was < 60 points.(Table 2)

According to literature data, the goal of rehabilitation of patients with shoulder hemiarthroplasty is to achieve
- elevation of 140°,
- external rotation of 40°
- and internal rotation with the thumb at the level of L 2 vertebra.

**COMPLICATIONS**

In the literature, primarily mentioned complications of shoulder hemiarthroplasty with fracture are:
1. The migration of a large tuberculum, superior and posterior
2. No healing of large and small tuberculum to each other or with the diaphysis of the humerus
3. Bone resorption of large tuberculum
4. Bone ossification
5. Nerve lesions
6. Prosthesis luxation
7. Deep infection.

Boileau and Walch, who processed the largest series of shoulder hemiarthroplasty with fractures - 188 cases, believe that the migration of tuberculum is the major reason of poor results, and that migration itself is a consequence of non coalescence of a large tuberculum with diaphysis of humerus and a small tuberculum due to poor positioning of the prosthesis - whether the prosthesis is too much elevated or that the angle of retroversion is greater than 20°. The consequence of this complication is poor functional result with insufficient movements in the shoulder,

**TABLE 2**

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<th>Points</th>
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<tr>
<td>&gt;90</td>
<td>(150°-180°)</td>
<td>excellent</td>
</tr>
<tr>
<td>80-89</td>
<td>(120°-149°)</td>
<td>very good</td>
</tr>
<tr>
<td>60-79</td>
<td>(90°-119°)</td>
<td>good</td>
</tr>
<tr>
<td>&lt;60</td>
<td>(&lt;90°)</td>
<td>bad</td>
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and the appearance of pain. The other authors in their work also speak about the importance of correct positioning of the prosthesis in regard to non coalescence, or resorption of a large tuberculum.

In our 34 cases of shoulder hemiarthroplasty we had the following complications:
1. In 2 patients (5.8%) - heterotopic ossification below the lower pole of the head, which are mentioned in the literature.
2. In 1 patient (3%) - distal subluxation of the head due to prosthesis placed too low
3. In 1 patient (3%) - deep infection, which in further course required the removal of the prosthesis.
4. We did not have cases of nerve lesions or prosthesis luxation. What we noticed more often was a progressive superior protrusion of the prosthesis head with narrowing of the subacromial space.

This phenomenon usually occurs 5-6 months post surgery and progresses gradually, so that the head is lifted in relation to the glenoid for 6-8 mm. Usually this disorder of joint congruence does not affect the function of shoulder nor causes pain. We did not find the explanation for this phenomenon in the literature, although it is also mentioned with other authors to the incidence of 25% -35%. We found it in one third of our patients.

We think that the proximal humerus migration occurs due to hypotrophy of supraspinatus, i.e. occurs in those cases where the large bump has a small mass with poor vascularization. Thinning of soft tissue cushion between the upper pole of the prosthesis head and the lower surface of the acromion allows the migration of humerus in upward route.

From the moment when with change in design of the prosthesis the space for adaptation of a fragment of the large tuberculum is fully provided, and thus obtained a higher bone mass with better potential for healing with surrounding bony structures- this complication occurred only occasionally, with elevation of the prosthesis head for only 2-3 mm.

**DISCUSSION**

Boileau and Walch in their book "Shoulder Arthroplasty" I from 1999., say that with the exception of two series published by Neer (1970 and 1988), all other writers speak of poor functional results of shoulder hemi-
arthroplasty with fracture. They also present a general view that the installation of partial shoulder prosthesis with fracture, is the intervention that still has a reputation for high-risk surgery and that the results of this intervention is often poor and unpredictable.17,18,19,20 (Table 3)

**CONCLUSION**

The maximum possible restitution of shoulder function in patients with hemiarthroplasty is provided with:
- the quality of conducted surgery
- early started, adequate kinesiotherapeutic protocol, implemented long enough
- a good motivation of patients for the treatment.

**REZIME**

**REHABILITACIJA HEMIARTROPLASTIKE RAMENA KOD PRELOMA**

Prelomi gornjeg okrajka humerusa su relativno česti. Predominantni su kod ženske populacije (85%), starosti prekpo 50 godina, gde je sila koja dovodi do preloma u 90% slučajeva umerena. Multifragmentarni (tro i četverodelni) prelom gornjeg kraja humerusa neoperativno lećen često ostavlja za sobom značajan invaliditet. Materijal i metod rada: U periodu od oktobra 2003. - 2010. godine sprovedena je rehabilitacija 34 bolesnika sa hemiartooplastikom ramena. Rezultati: Postignuti rezultati praćeni su i preciznom evaluacijom Constant-skorom posle šestog meseca od operacije. Njime se sistemom bodovanja procenjuje bol, mobilnost zgloba ramena, funkcionalna evaluacija ruke i snaga stiska šake. Kod 25 bolesnika (73,5%) Constant-skor je bio >90 bodova. Kod 7 bolesnika (20,6%) je bio 80-89, dok je kod 2 bolesnika (5,9%) vrednost Constant-skora bila <60 bodova. Zaključak: Maksimalno moguća restitucija funkcije ramena kod bolesnika sa hemiartooplastikom obezbedjuje se:
- kvalitetno sprovedenim operativnim zahvatom
- rano započetim, adekvatnim kineziterapijskim protokolom, koji se sprovodi dovoljno dugo
- dobrom motivacijom bolesnika za lečenjem

Ključne reči: prelomi proksimalnog kraja humerusa, hemiartooplastika ramena, rehabilitacija

**BIBLIOGRAPHY**