



Professional article

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SHOULDER ARTHROPLASTY FOR FRACTURES AND SIGNIFICANCE OF EARLY REHABILITATION

SUMMARY

One of the bone-joint injuries, which if operatively untreated often causes invalidity, can be a multifragmented, dislocated fracture (three- and four-part) of the upper end of the humerus. The attitude of Department of Shoulder Surgery (at the Institute of Orthopedic Surgery and Traumatology, CCS in Belgrade) is that all proximal humeral fractures should be surgically treated, except those with tolerable dislocation, or because of contraindications for other reasons.

Three- and four-part fractures with significant dislocations of fragments, fractures complicated with head dislocation, and patients over 60 years of age are treated by implanting partial shoulder prosthesis - with haemiarthroplasty.

Since 1985, over 700 patients with fractures on the upper end of humerus have been operated on. Over 180 of these were three-part and four-part fractures. Around 30% of these fractures were complicated with humeral head dislocation. Apart from acute fractures, there were about 5% of chronic cases with proximal humerus pseudoarthroses or avascular necroses of the humeral head.

In 64 patients, these fractures were treated with shoulder hemiarthroplasty. In others we used osteosynthesis with a wire-loop, "T" plate, "L" plate, or a combination of the plate and wire. We conducted the first shoulder hemiarthroplasty in 1989.

In this paper, we discussed our 16-year-long experience in the use of partial prosthesis with multifragmented shoulder fractures. We will explain the significance of precise reconstruction and firm fixation of both tuberosities, the significance of proper positioning of the prosthesis, as well as the type or shape of the prosthesis. We consider a new approach of early rehabilitation program to be very significant for attaining the maximal functional restitution of the shoulder.

Key words: proximal humerus fractures, surgical treatment, shoulder hemiarthroplasty

INTRODUCTION

The attitude of Department of Shoulder Surgery (at the Institute of Orthopedic Surgery and Traumatology CCS in Belgrade) is that all proximal

humerus fractures should be surgically treated, except those with tolerable dislocation, or because of contraindications for other reasons.

Three-part and four-part fractures with significant dislocations of fragments, fractures

complicated with head dislocation, and patients over 60 years of age are treated by implanting partial shoulder prosthesis - with hemiarthroplasty.

Since 1985, over 700 patients with fractures of the upper end of the humerus have been operated on. Over 180 of these were three-part and four-part fractures. Around 30% of these fractures were complicated with the humeral head dislocation. Apart from acute fractures, there were about 5% of chronic cases with proximal humerus pseudoarthroses or avascular necroses of the head of the humerus.

In 64 patients, these fractures were treated with shoulder hemiarthroplasty. In others, we used osteosynthesis with a wire-loop, "T" plate, "L" plate, or a combination of the plate and wire. We conducted the first shoulder hemiarthroplasty in 1989.

At 12th Orthopedic Conference of Yugoslavia, in November 2001 in Kladovo, we presented a paper discussing surgical treatment of three and four-part fractures of the proximal humerus. We discussed our broad positive experience with open reduction and fragment fixation with a wire-loop and our negative experience with treating similar cases with shoulder hemiarthroplasty.

We presented 18 patients with implanted partial shoulder prosthesis for fractures. We used mainly the partial prosthesis "Beznoska". In 4 cases we used Neer I type, and in 2 patients Neer II type. Postoperatively, we immobilized our patients with Velpeau sling. They began with physical therapy between the third and fourth week, most often in a nearby health center. We were not satisfied with obtained functional results. Six months after the operation and physical therapy, the range of accomplished active anteflexion was between 50 and 100 degrees. Exactly: in 3 operated patients (16.6%) we reached an active anteflexion of 90-100 degrees, and in the remaining 15 (83.3%) the active anteflexion was 50-85%.

Boileau and Walch in their book "Shoulder Arthroplasty" (1) from 1999, state that all authors report poor results of shoulder hemiarthroplasty for fractures, except two series published by Neer (2, 3) in 1970 and 1988. Those authors (except Neer) state their general attitude that the implantation of partial shoulder prosthesis for fractures is a type of intervention that still has a reputation of a risky procedure, and that the results of these procedures are often poor and unpredictable.

Functional results of shoulder hemiarthroplasty for fractures in medical literature

Poor results of shoulder hemiarthroplasty in our patients did not discourage us, instead they stimulated our research.

Analyzing the results we noticed that the mass of the greater tuberosity fragment was very significant for the functional recovery of the shoulder. Specifically, greater tuberosity, with the attached supraspinatus, facilitates better utilization of forces and allows easier arm elevation. The shape of the prosthesis with a fin on the "back" of the stem which we mostly used with 18 initial cases required further thinning of tuberosity during the fragment adaptation. This was probably one of the reasons for the weakening of the arm elevation mechanism. Fortunately, we noticed that a vast majority of manufacturers has this shape of the proximal end of prosthesis.

At the beginning of 2002, we removed this fin and a part of the back of the prosthesis and got an adequate space for adaptation of greater tuberosity (Figure 1).

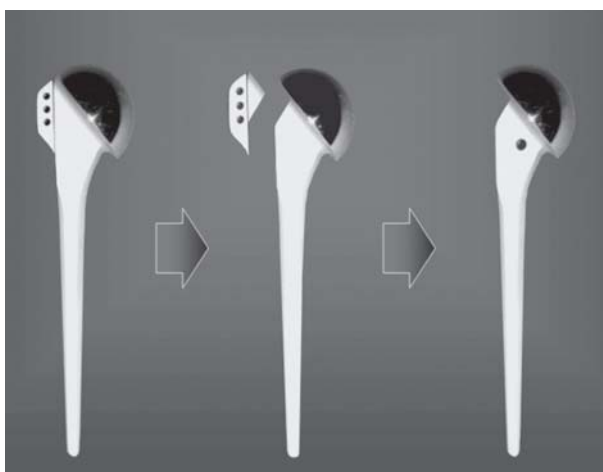


Figure 1. Having removed the fin and a part of the "back" of the prosthesis, we got an adequate space for adaptation of greater tuberosity

Thus, until the end of 2003, we had additional 20 shoulder hemiarthroplasties with this modified shape of the prosthesis neck. The functional results became evidently better. In comparison to 50° -100° anteflexion (75° on average) up until that point, we reached an active anteflexion of 110° -140° (125° on average).

Based on our experience about advantages and disadvantages of certain models of shoulder prosthesis that we implanted, we created (in mid 2003) an original model of partial shoulder prosthesis of ideal characteristics.

The prosthesis is modular, with the choice of 4 head sizes. It is made of titanium (Figure 2).

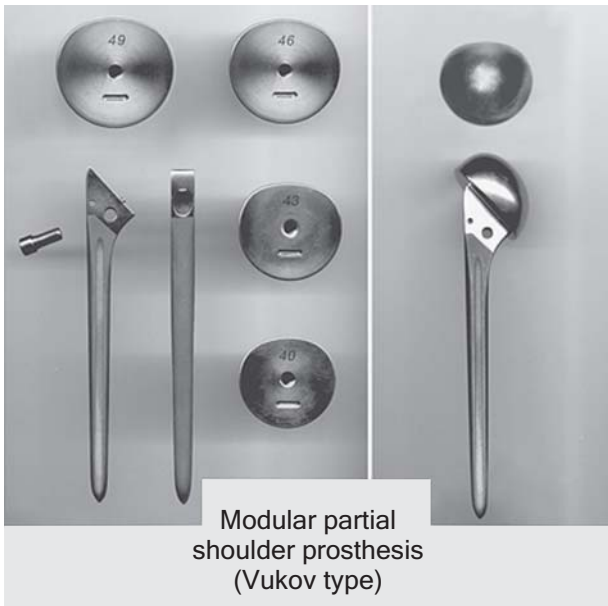


Figure 2. The prosthesis is modular, with the choice of 4 head sizes. It is made of titanium.

The head of the prosthesis is not completely spherical - it has a smaller angle of curvature on the upper pole towards the subacromial space (Figure 3).



Figure 3. The head of the prosthesis is not completely spherical. It has a smaller angle of curvature on the upper pole.

This type of head reduces the pressure on the supraspinatus tendon, and changes the kinetics of movements in terms of easing the arm elevation in the zone of 90°-100°. We designed four standard sizes of head module of 40, 43, 46 and 49 mm in

radius. The stem of the prosthesis is universal for all 4 head sizes. It is designed precisely so that the curvature of the medial side (on its upper end) completely matches the anatomical curve of the medial cortex of the distal humerus fragment (Figure 4). Thus designed medial side of the stem reduces the error of the vertical positioning of the prosthesis. Dimensions of the stem are such that it can be placed in each distal fragment of the humerus in adults.



Figure 4. The prosthesis is precisely designed, so that the curvature of the medial side of the stem matches the anatomical curve of the medial cortex of the shaft of the humerus

The model of the prosthesis has been patented, and the prosthesis evaluated regarding its material at the School of Mechanical Engineering, University of Belgrade. The prosthesis satisfies the established standard (ISO 5832-3) for the implantation into the human body. During 2003, we implanted 5 of these prosthesis. Due to new laws, we cannot use it, and we are currently negotiating with certain manufacturers.

Our Attitudes

Based on our experience, we hold that there are four reasons for reaching the maximal possible functional recovery of the operated shoulder:

1. Choosing the right model of the prosthesis.
2. An adequate positioning of the prosthesis.
3. Quality fixation of greater tuberosity and reconstruction of rotator cuff.

4. An early rehabilitation with well-chosen kinesitherapy protocol.

An adequate prosthesis model selection

There are three components of the prosthesis that one needs to be aware of:

1. The prosthesis head, where four sizes (40, 43, 46, 49mm) satisfy the needs of our population.

2. The "back" of the prosthesis. We already saw how much and why was the empty space in the back region of the prosthesis important for the success of the operation.

3. The prosthesis stem, in terms of its thickness, length and shape. The opening on the upper portion of the stem is necessary for putting through the wire loop during the fixation of the fragments. If greater and lesser tuberosities are not firmly fixed to the stem, an early physical treatment is impossible.

An adequate positioning of the prosthesis

Here, two aspects must be emphasized:

1. Positioning of the prosthesis to an adequate height so as to establish a normal relationship between the head of the prosthesis and the glenoid.

2. An adequate angle of the retroversion of the prosthesis.

According to many authors, a precise vertical placement of the prosthesis is extremely important. Too high positioning of the prosthesis reduces the subacromial space, leading to shoulder pain. A common consequence is nonunion of greater tuberosity, which further leads to its migration, its resorption and limitation of the movements accompanied with shoulder pain (4,5,6). Bualo and Welch designed a special apparatus (the Aequalis fracture jig), which facilitates practically an ideal height and retroversion of the prosthesis (7). In our experience, it is much more common to set prosthesis lower (deeper) because of the absence of proximal anatomical landmarks in three- and four-part fractures. This causes a distal subluxation of the head. In the postoperative period, this subluxation is usually spontaneously corrected during rehabilitation (2-3 weeks after). However, if it is significant (more than 1/2 of the head), it might slow down and make the rehabilitation difficult.

The angle of retroversion varies from author to author, from 20 degrees to 40 degrees. Some authors hold that incorrect retroversion of the prosthesis leads into migration of greater tuberosity and poor functional result (8, 9). We noticed that the angle of retroversion of 15-25 degrees provided an

optimal shoulder mobility. We did not notice that the partial diversion from an ideal retroversion of the prosthesis was the reason of greater tubercle nonunion. In our experience, some other aspects (that will be discussed later) were responsible here.

Anatomical reconstruction of tuberosities

In our experience, there are several factors facilitating quality union of the bone fragments: a good adaptation and tight mutual fixation of tuberosities, their fixation for the stem of the prosthesis and especially firm fixation of the tuberosity to the shaft. Therefore, we paid special attention to this problem, by using a soft wire 0.6-0.8mm. It is very important to preserve the mass of greater tuberosity. If it is insufficient, one should put cancellous bone from the head of the humerus between tuberosity and the stem of the prosthesis.

Early rehabilitation with well-chosen kinesitherapy protocol

By the end of 2003, a new approach-early rehabilitation, with the shoulder surgery was agreed upon. Until then, the patients with shoulder hemiarthroplasty were sent home on the 6th day postoperatively. They were immobilized with the sling and the patients started with physical therapy, as outpatients, 3-4 weeks after the operation.

With the new approach, the physical therapy begins the next day after the operation. We applied a specific kinesitherapy protocol, which emerged from a combination of Neer's protocol with shoulder arthroplasty and the protocol from John Hopkins University in Baltimore. With new experiences, we changed an established original system and modified duration of certain treatment phases, so that some periods were shortened. Therefore, the entire process of rehabilitation was considerably accelerated.

We implemented physical exercises twice a day, in duration of 20-30min. Operated patients remained hospitalized for four weeks approximately, which depended on the progress of the physical therapy.

The protocol contains three phases:

1. *The first phase* is aimed at reduction of pain and swelling, increasing the range of shoulder movements and education about protective position. This phase usually lasts until the end of the forth postoperative week. In addition to specific exercises for the shoulder region, encompassing pendular, passive, self-assisting and isometric exercises, we utilize active exercises for elbow, hand and fingers, too.

With pendular exercises we improve muscular relaxation.

With passive exercises, an anteflexion of 90 degrees was accomplished till the second post-operative week. The outer rotation was thus avoided.

Self-assisting exercises are accomplished with a healthy arm or a stick. One performs the movements of frontal elevation, outer rotation, abduction and ante-flexion. Exercises with attached hands behind occipitum and elbows moving backwards in synergy activate trapezius muscle, rhomboideus muscle, posterior portion of deltoid muscle and spinal musculature. This is called the siesta position. Completely performed siesta position means a total recovery of outer rotation and adequate elasticity of the frontal joint capsule.

Isometric exercises of flexion, abduction and outer and internal rotation in lying, sitting and standing positions are started two weeks postoperatively. During the third week, the program expands with exercises involving »pulli-apparatus«. 2. *The second phase* lasts 5-10 weeks, and its aim is to reduce pain, increase active movement of the shoulder and improve functional activity. In this particular phase, we start with active exercises, exercises of strength and stretching exercises. All exercises from the previous phases continue.

3. *The third phase* begins from week 11. We emphasize the importance of increasing the muscle strength and improvement of shoulder coordination control during the activities in an everyday life.

We conduct this program for 3 months and follow the patient the following 9 months during which he/she exercises at home. During the first 4 weeks in the hospital, the work on the program is team-based, including an everyday cooperation between the orthopedic surgeon, physiatrist and the therapist. The motivation of the patient is especially important for the treatment success.

Leaving the hospital, the patients continues with exercising at home. In addition, their progress is promptly checked by physiatrist. The results are evaluated with Constant score. We follow our patients up until one year post-operatively.

Kinesitherapy protocol, which we apply in shoulder hemiarthroplasty, is a fundamental model that sometimes requires corrections.

Results of shoulder hemiarthroplasty by using an early physical therapy

During the past two years (2004 and 2005), we have had 16 patients with shoulder hemiarthroplasty under the regime of early physical therapy. We reached surprisingly good results. The patients were leaving the hospital 4 weeks after a continuous

kinesitherapy program, experiencing a painless full or nearly full self-assisted anteflexion. Thirteen patients left the clinic with a subjective remark "very satisfied", and another 3 patients with the subjective remark "satisfied".

Shoulder hemiarthroplasty was done in the following cases: Neer-4 in 5 patients, Neer-4 fracture - dislocation in 4 patients, Neer-3 (male sanata) in 1 patient, Neer-4 (malunion) in 2 patients, Neer-2 (pseudoarthrosis) in 2 patients and Neer-4 (avascular necrosis) in 2 patients.

In these 16 patients we used 7 redesigned partial prostheses "Beznoska", 5 modular partial prosthesis type Vukov and 4 partial prosthesis "Link" without fin.

We conducted patient check-ups for 3 months, 6 months and 1 year after the operation. We examined active movements of anteflexion, of abduction, outer and inner rotation, presence of pain and strength of the extremities. Obtained active anteflexion and the presence of pain were main parameters for statistical evaluation.

Obtained results were followed with a precise evaluation by using the Constant-score, six months after the operation. With this assessment instrument one can evaluate pain, shoulder joint mobility, functional capabilities of an arm, and the strength of the handshake. In 14 patients (87.5%), the Constant score was >90 points (excellent). In 2 remaining patients (12.5%), the score was 85 and 86 (very good).

Complications

Complications of shoulder hemiarthroplasty are in literature (10,11,12,13,14,15) known as:

1. Superior and posterior migration of large tuberculum.
2. Nonunion between the tuberosities and the diaphysis.
3. Bone-resorption of greater tuberosity.
4. Heterotopic ossification.
5. Nerve lesions.
6. Luxation of the prosthesis.
7. Deep infection.

Bualo and Welsh, who performed the largest series of shoulder hemiarthroplasties on fractures (188 cases), hold that the migration of tuberosities is the main reason for poor results. Migration of tuberosities is a consequence of nonunion of greater tuberosity with the shaft and with lesser tuberosity. The main reason for this are the mistakes in prosthesis positioning in height, and/or excessive retroversion. A consequence of this complication is a poor functional result with insufficient shoulder movements and appearance of pain (16). Other

authors discuss the importance of proper prosthesis positioning in relationship to nonunion or resorption of greater tuberosity, too (5, 15, 17, 18).

In our experience, the migration of greater tuberosity is a consequence of insufficiently firm fixation of greater tuberosity for the stem of prosthesis and the shaft of the humerus. Also, the migration results from impossibility to conduct good adaptation of tuberosity due to poor design of the prosthesis. A vast majority of models for shoulder prosthesis has "fin with openings" on the back of the stem, which disallows a quality adaptation and fixation of tuberosities.

In our 64 shoulder hemiarthroplasties, we had the following complications:

1. In 9 patients (18,4%) we had resorption of greater tuberosity, while we used original prosthesis "Beznoska" with the fin on the back of the stem.
2. In 7 patients (14,3%) we had heterotopic ossification under the lower pole of the prosthesis head.
3. In 5 patients (10,2%) we had a distal subluxation of the head due to low positioning of the prosthesis, whereas in one patient the subluxation was below $\frac{1}{2}$ of the head.
4. In 3 patients (4,69%) we had seromas at the surgical cut.
5. In 2 patients (3,12%) we had a deep infection, which led into the removal of the prosthesis.

We did not see the nerve lesions, or luxation of the prosthesis. What we have more frequently seen is a progressive proximal migration of the humerus, with the narrowing of subacromial space. This

phenomenon usually occurs 5-6 months post-operatively and slowly progresses, so that the head of prosthesis becomes raised in relationship to glenoid, for 6-8 mm. Usually, the loss of congruency of the joint neither affects the shoulder function nor it causes pain. In literature, we did not find explanation for this phenomenon, even though it is mentioned by other authors in 25-35% cases (19). We found this phenomenon in 1/3 of our patients.

We think that the proximal migration of the humerus occurs due to hypotrophy of the supraspinatus, that is if greater tuberosity has a small mass with poor vascularization. Thinning the soft-tissue pillow between the upper pole of the prosthesis and lower surface of the acromion allows proximal migration of the humerus.

When we modified design of the prosthesis and got more space for adaptation of greater tuberosity, we got a larger bone mass with a better potential for union with surrounding bone structures. From the moment we made this alteration in design, the previously mentioned complication have occurred rarely, with proximal migration of the humerus for only 2-3 mm.

CONCLUSION

The success of shoulder hemiarthroplasty in three- and four-part fractures of the proximal humerus depends first and foremost on the appropriate model of the prosthesis, on precise reconstruction and firm fixation of tuberosities, on adequate positioning of the prosthesis and especially on well-chosen kinesitherapy protocol with permanent cooperation of the orthopedic surgeon, physiatrist, therapist and the patient.

REFERENCES

1. Walsh G and Boileau P (Eds.) *Shoulder Arthroplasty*, Springer, 1999.
2. Neer CS II. Displaced proximal humeral fractures. II Treatment of three and four part displacement. *J Bone Joint Surg Am* 1970; 52:1090-1103.
3. Neer CS, Mcliven SJ. Remplacement de la tete humerale avec reconstruction des tuberosités et de la coiffe des rotateurs dans les fractures déplacées à 4-fragments. Résultats actuels et technique. *Rev Chir Orthop* 1988; 74 [Suppl II]: 32-40.
4. Tanner MW, Cofield RH. Prosthetic arthroplasty for fractures and fracture dislocations of the proximal humerus. *Clin Orthop* 1983; 179: 116-128.
5. Bigliani LU, Flatow EL, Mc Cluskey, Fischer RA. Failed prosthetic replacement for displaced proximal humeral fractures. *Orthop Trans* 1991; 15: 747-748.
6. Muldon MP, Cofield RH. Complications of humeral head replacement for proximal humeral fractures. *Instruct course Lect* 1997; 46:15-24.
7. Boileau P, Walsh G. The Aequalis Fracture Jig. *Surgical Technique Overview*. Tornier Inc, France, 1995.
8. Boileau P, Hutten D. Technique chirurgicale des prothèses de Neer pour fractures céphalo-tubérositaires. *Rev Chir Orthop* 1995; 81 [suppl II]: 85-88.
9. Boileau P, Walsh G. Prothèses d'épaule pour fractures: Problèmes et solutions. *Maitrise Orthop* 1996; 6:18-23.
10. Tanner MW, Cofield RH. Prosthetic arthroplasty for fractures and fracture dislocations of the proximal humerus. *Clin Orthop* 1983; 179: 116-128.
11. Cofield RH. Comminuted fractures of the proximal humerus. *Clin Orthop* 1988; 230: 49-57.
12. Craig EV. Prosthetic replacement for four part fractures of the proximal humerus. *Tech Orthop* 1989; 3: 70-80.
13. Moeckel BH, Dines DM, Warren RF, Altchek DW. Modular hemiarthroplasty for fractures of the proximal part of the humerus. *J Bone Joint Surg Am* 1992; 74: 884-889.
14. Green A, Barnard WI, Imbird RS, Providence RI. Humeral head replacement for acute four-part proximal humerus fractures. *L Shoulder Elbow Surg* 1993; 2:249-254.

15. Compito CA, Self EB, Bigliani LU. Arthroplasty and acute shoulder trauma, reasons for success and failure. *Cin Orthop* 1994;307: 27-36.

16. Boileau P, Walsh G. Three dimensional geometry of the proximal humerus implications for the surgical technique and prosthetic design. *J Bone Joint Surg* 1997; 79B: 857-865.

17. Pietu G, Deluzarches P, Goin F, Letenneur J. Traumatismes complexes de l'extrémité supérieure de l'humérus traités par prothèse céphalique: à propos de 21 cas revus avec un recul moyen de 4 ans. *Acta Orthop Belg* 1992; 58:159-169.

18. Hutten D, Boileau P, Bonneville P, Maynou C, Renault E, Vogt F, Postel JM, Candelier G, Fleure P. Résultats et omdocatopms de l'arthroplastie prothétique dans les fractures récentes complexes de l'extrémité supérieure de l'humérus. *Conférences d'Enseignement de la SOFCOT Expansion Scientifique Française, Paris, 1996; pp 125-140.*

19. Ianoti SR, Gabriel JP, Schneck SL, Evan BG, Miras S. The normal glenohumeral relationships. An anatomical study of one hundred and forty shoulders. *J Bone Joint Surg Am* 1992; 74: 491-500.

HEMIARTROPLASTIKA RAMENA KOD PRELOMA I ZNAČAJ RANE REHABILITACIJE

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SAŽETAK

Stav Odeljenja za hirurgiju ramena, Instituta za ortopedsku hirurgiju i traumatologiju KCS u Beogradu je da većinu preloma gornjeg kraja humerusa treba operisati, osim one sa tolerantnom dislokacijom fragmenata ili zbog kontraindikacija iz drugih razloga.

Kod trodelnih i četvorodelnih preloma sa značajnom dislokacijom, naročito kod osoba starijih od 60 godina i posebno kod luksacionih preloma, pribegavamo imedijatnoj implantaciji parcijalne proteze ramena.

Od 1985. do danas, na Institutu za ortopedsku hirurgiju i traumatologiju KCS u Beogradu operisano je preko 700 bolesnika sa prelomima na gornjem kraju humerusa od kojih je preko 180 bilo trodelnih i četvorodelnih preloma. Oko 30% ovih bolesnika imalo je komplikovane luksacione višedelne prelome. Pored akutnih preloma bilo je i oko 5% hroničnih slučajeva sa pseudoartrozom proksimalnog humerusa ili avaskularnom nekrozom glave humerusa.

Kod 64 bolesnika, ovi prelomi su lečeni hemiartroplastikom ramena, dok je kod ostalih rađena osteosinteza žičanom omčom, „T“ pločom, „L“ pločom ili kombinacijom ploče i žice. Prvi put smo hemiartroplastiku ramena uradili 1989. godine.

U ovome radu izneli smo naše šesnaestogodišnje iskustvo u korišćenju parcijalnih proteza kod multifragmentarnih preloma na ramenu. Objasnićemo značaj precizne rekonstrukcije i čvrste fiksacije velikog i malog tuberkuluma, značaj pravilnog pozicioniranja proteze, kao i tipa, odnosno, oblika proteze. Smatramo posebno važnim nov pristup u smislu rane rehabilitacije, jako bitne za postizanje maksimalne funkcionalne restitucije ramena.

Ključne reči: prelomi proksimalnog kraja humerusa, hirurško lečenje, hemiartroplastika ramena