REVERSE SHOULDER PROSTHESIS: IMPLEMENTATION AND EXPERIENCE IN CROATIA

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SUMMARY – Reverse shoulder prosthesis has become one of the most often used prosthetic implants in shoulder replacement surgery. It has a wide spectrum of indications, starting from comminuted humeral fractures and posttraumatic arthritis to arthritis caused by the rotator cuff loss. Its application at our hospital began in 2004, at first in few specific cases and with time in ever growing number of patients. Over 8 years, more than 250 reverse shoulder prostheses were implanted at our institution. In addition, our surgeons supervised its application in other hospitals all over Croatia. In the postoperative course, the shoulder was immobilized for 4-6 weeks with a thoracobrachial cast. After removal of the cast, physical therapy was initiated. The length of physical therapy program depended upon many factors. As a rule, immobilization lasted longer in patients that were operated on due to posttraumatic arthritis and those that suffered from deltoid muscle atrophy and shoulder contracture before surgery. Complications included dislocation of the prosthesis shortly after surgery (in the first four weeks) and infection. Infection was a special problem and treatment included even explantation of the prosthesis.

Key words: *Shoulder fractures; Shoulder joint – surgery; Arthroplasty replacement – methods; Croatia*

Introduction

What is reverse shoulder prosthesis? It is a non-anatomic prosthesis type consisting of a half-globe implanted into the glenoid and a reverse body implanted into the humerus. The inverse body has a concave shape and adheres to the half-globe. The inverse body is positioned at a small angle (155 degrees) towards the axis of the humeral diaphysis, so that after insertion no proximal shifting of the humeral prosthesis component by the deltoid muscle pulling forces is allowed. Medialization and distalization of the center of rotation are two basic principles. The center of rotation shifts from the center of the humeral head towards the glenoid, the deltoid muscle is extended, and its ability to abduct the upper arm is increased. Due to medialization, a larger portion of its anterior and posterior fibers are mobilized for abduction[1].

Initially, it was designed to treat severe arthritis of the rotator-cuff deficient shoulder[2]. Today, it has become widely used for many painful arthritic and rheumatic conditions, posttraumatic conditions and acute comminuted fractures of the proximal humerus in the elderly.

In the sixties and seventies, results of treatment of shoulder joint arthropathy by hemiarthroplasty were often unreliable. Consequences comprised limited function, pain and progressive glenoid erosion[3,4]. Total shoulder arthroplasty was burdened with frequent loosening of the glenoid component due to the rocking horse phenomenon. Franklin *et al*. have reported that this phenomenon caused loosening of the glenoid component in as many as 50% of cases[5].

New designs of shoulder prosthesis introduced in the seventies and eighties tried to solve old problems.

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Many different types of prosthesis were designed including the reverse prosthesis and even the so called hinge-design. Kessel[6] and Fenlin[7] designed a reverse prosthesis with the center of rotation moved more laterally than in the current prosthesis types. All these prosthesis types were associated with a high rate of complications, loosening of the glenoid component in particular[8]. Only the prosthesis designed by Paul Grammont (Dijon, France) managed to survive[9]. Contrary to the preceding reverse prosthesis designs, Grammont eliminated the neck of the glenoid component, created a half-globe and attached it to the glenoid, thus shifting the center of rotation towards the midline. In this way, the shearing forces were lowered and the forces of compression onto the glenoid were increased. His Delta III prosthesis (De Puy) introduced into practice in 1992 is still in use and yields good results with a low rate of component loosening. Shortly after that, a similar design was launched to the market by the Tournier Company (Acqualis reverse prosthesis). Indications were soon extended to other rheumatic and traumatic conditions of the shoulder joint, so that this prosthesis type was also used as the reverse prosthesis. Today, each manufacturer of orthopedic implants has its own shoulder prosthesis design that is basically not much different from the original Grammont design.

Indications include the following conditions: massive rotator cuff ruptures, four-part fractures of the proximal humerus with displacement in the elderly, revision surgery of the shoulder, upper arm tumors, and rheumatoid arthritis[10-23].

At the University Department of Traumatology, Sestre milosrdnice University Hospital Center, Zagreb, Croatia, the most common indication for the implantation of reverse shoulder prosthesis is fracture of the proximal humerus in the elderly in cases where internal fixation is not possible. It is a mistake to choose internal fixation to treat a fracture if it is doomed to fail. Each failed internal fixation of the proximal humerus is associated with pains and loss of function. After some time, posttraumatic arthritis develops[10] with subsequent pains, so that secondary operative procedure is mandatory. Revision surgery is a major risk for the elderly patient, let alone doubled costs of treatment. In addition, results of primary shoulder arthroplasty are superior to secondary shoulder arthroplasty.

Further, an absolute indication for prosthetic replacement is fracture of the humeral head itself, i.e. fracture and dislocation of the calotte by more than 2 cm in four-part fractures.

A relative indication is a four-part fracture of the humerus with displacement in elderly patients. However, the indication for surgery should be established by the most experienced surgeon in this type of surgery, based on thorough evaluation of the patient's condition. Sometimes, it is best not to operate, especially in aged patients with major comorbidities.

The second most common indication for prosthetic replacement is posttraumatic arthritis associated with humeral head loss due to aseptic necrosis[10]. In such a case, arthritis may be a consequence of postoperative complications, failed internal fixation or malposition of fracture fragments in patients treated non-operatively. Another indication is a condition following unrecognized or untreated anterior or posterior shoulder displacement. The structure of humeral head is weaker than the structure of the neighboring glenoid. If displacement lasts, the glenoid margin erodes the humeral head and reduces its circumference and congruity step by step.

Arthritis caused by rotator cuff loss is the third most common indication. The function of the rotator cuff is stabilization of the humeral head during elevation of the upper arm. Its loss or rupture leads to degenerative changes in the glenohumeral joint due to proximal pulling of the humeral head by deltoid muscle. This condition is referred to as impingement syndrome. In severe cases, this syndrome results in loss of shoulder joint function, impossibility of upper arm elevation, persisting pains and muscle atrophy of the shoulder girdle. Treatment of rotator cuff-deficient shoulder is the very reason why the reverse shoulder prosthesis has been invented.

The fourth indication for implantation of the reverse shoulder prosthesis is revision surgery following anatomic partial or total shoulder arthroplasty. The reverse shoulder prosthesis offers solutions for almost all severe conditions affecting shoulder joint and it may even be used to treat tumors.

An absolute contraindication for reverse arthroplasty is a lesion of the axillary nerve and subsequent deltoid muscle paralysis. In such a case, arthrodesis is necessary in order to avoid the so called 'dropped shoulder'.

Partial shoulder prosthesis was introduced into practice at the Clinical Department of Traumatology, Sestre milosrdnice University Hospital Center, Zagreb, Croatia, in 2000. Indications for implantation were fractures of the proximal humerus unsuitable for treatment using internal fixation. Outcomes varied and depended more on the patient age and motivation to recover than on the operative technique quality. The most significant complication was nonunion in the tubercular region and subsequent anterior prosthesis instability or proximal shifting of the prosthesis upwards to the acromion, both resulting in pains and major reduction of the range of motion[19-22]. Fifteen to twenty prostheses were implanted each year by two surgeons. The experience of other hospitals on the one hand and our complications and poor results on the other urged us to insist on the introduction of reverse shoulder prosthesis into our daily clinical practice.

Material and Methods

In November 2004, the reverse shoulder prosthesis was implanted for the first time at our hospital (and also in the region), with the assistance of Dr. Ambacher, a surgeon working at the Katharinenhospital in Stuttgart, Germany. At that time, our hospital and Katharinenhospital had been cooperating for many years in the field of bone and joint surgery. A Delta prosthesis (Johnson & Johnson) was implanted in a young patient with posttraumatic postoperative arthritis. Two more Delta prostheses were applied in the next year. At the beginning of 2006, we decided to use a prosthesis manufactured by LIMA (SMR Shoulder System) since its price was by 30% lower. It was a modular system where the components could be combined depending on the prosthesis type, e.g., total anatomic, partial or reverse prosthesis. The prosthetic stem was made in two versions, cemented and uncemented. Owing to a simple implantation procedure and small difference in the price, uncemented prostheses were used. The number of implanted prostheses in 2006 exceeded 30 and continued to grow each year, so that in the year 2011 a total of 45 reverse shoulder prostheses were implanted.

A total of 208 patients operated on from November 2004 till December 2012 with shoulder prosthesis

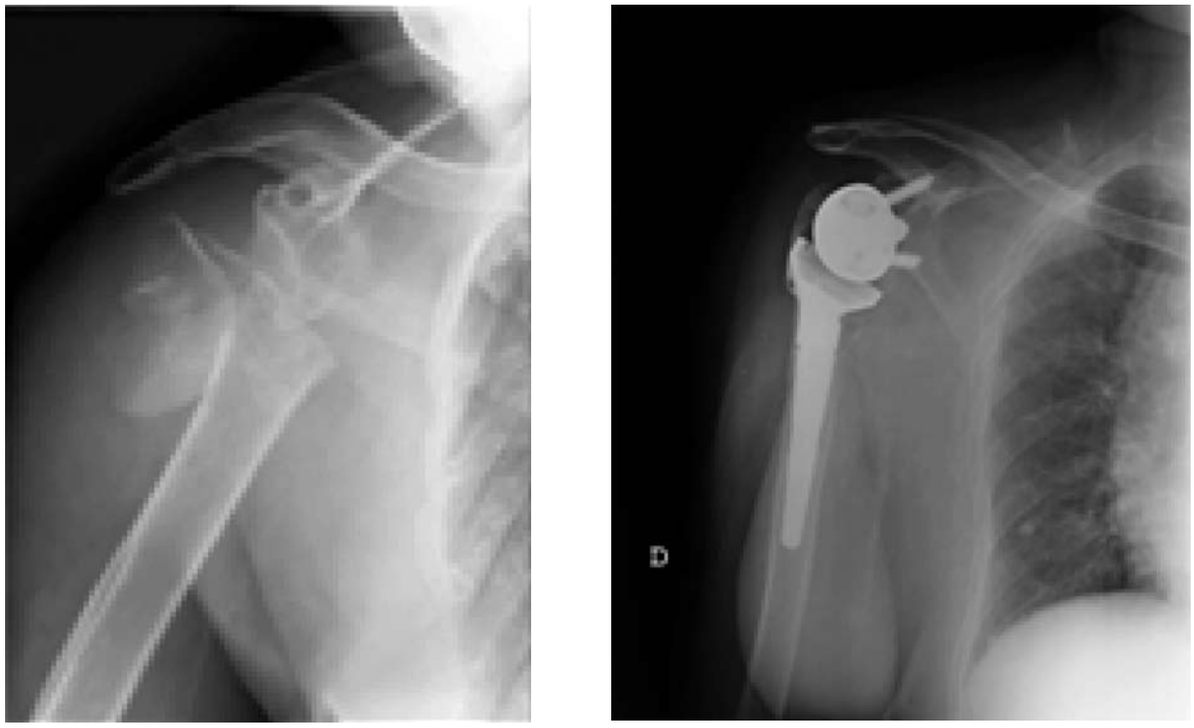

Fig. 1A, B. Indication for shoulder prosthesis implantation in the elderly: four-part fracture of the proximal humerus with displacement.

were studied. Our indications included the following conditions: massive rotator cuff ruptures, four-part fractures of the proximal humerus with displacement in the elderly (Fig. 1 A,B), revision surgery of the shoulder, upper arm tumors and rheumatoid arthritis[10-24]. The postoperative course comprised immobilization for 4-5 weeks in a thoracobrachial plastic cast with the upper arm in neutral rotation and 45 degree of abduction. After removal of the cast, physical therapy program was initiated. Patients were invited for follow up examination by the operating surgeon every 6 months. The range of motion, degree of pains, patient satisfaction with surgery, and x-rays of the shoulder were analyzed. The possible signs of impingement in the scapular neck were followed on x-rays, as well as signs of the possible loosening of the glenoid or humeral component of the shoulder prosthesis in addition to signs of bone destruction due to infection.

Results

Results are shown in Table 1. Twelve months after surgery, 129 (62%) patients did not complain of any pain and expressed a high degree of satisfaction with the results of treatment. The majority of these patients had a good range of motion and adequate muscle mass in the shoulder joint. The prosthesis was implanted to treat a fracture in the majority of these patients.

Sixty-six (32%) patients had intermittent pain that was successfully treated with analgesics. Twelve (6%) patients complained of constant pain and their range of motion was limited. The intensity of pain varied from patient to patient. Pain was less spontaneous and less intense during rest and more associated with specific movements in the shoulder joint, particularly during elevation. Degree of satisfaction with pain after the surgery was high because before shoulder arthroplasty these patients had been suffering severe pain caused by posttraumatic arthritis and arthropathy.

Table 1. Results after reverse shoulder prosthesis implantation

	n	n/N(208)
Infection	6	3.00%
Dislocation	20	9.60%
Component loosening	4	2.00%
ROM>referenced	112	54.00%
ROM=referenced	44	23.00%
ROM<referenced	52	25.00%
No pain	129	62.00%
Intermittent pain	66	32.00%
Constant pain	12	6.00%

ROM – range of motion

The following degrees of function and range of motion may be considered as good results: up to 160 degrees of elevation, internal rotation up to L5; and external rotation to the neutral position. In 112 (54%) patients, even better values were recorded. Forty-four (23%) patients had values around the mentioned parameters and the remaining 52 (25%) below these parameters.

Complications we encountered were the following: infection, prosthesis dislocation, loosening and instability of the humeral or glenoid component. On the other hand, scapular notching and fractures of the acromion we had none. Infection developed in six (3%) patients. Coagulase negative staphylococcus was isolated twice and *Staphylococcus aureus* once. All other smear cultures were negative. All smears were taken intraoperatively. A typical site of infection was between the plastic implant and reverse body, and between the glenosphere and metal back (5 patients); only in one female patient infection was located in the humeral stem. Laboratory findings (complete blood count (CBC), erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP)) were evaluated in all of these patients. None of our patients developed infection in the early postoperative course. Infection occurred after minimum of 3 months to 3 years.

Prosthesis dislocated in 18 (8.6%) patients in the early postoperative period (less than 4 weeks) and two patients suffered two dislocations. Later in the postoperative course (after 4 weeks) there were only 2 (1%) dislocations attributable to aggressive physical therapy. Clinical signs of instability included pains and function loss, and x-rays also confirmed dislocation. In our patient series, there were only 3 (1.4%) cases of humoral stem loosening and one case where loosening was associated with infection. We also had one (0.5%) case of glenoid component loosening and breaking of the screws, which was successfully managed by revision surgery and implantation of another prosthesis type.

Discussion

Zumstein *et al.*[25] have reported on 182 complications in 782 (24%) cases. Most frequent complications were instability (4.7%) and infection (3.8%). All these complications occurred in our patients and we tried to solve them in the best possible way. Infection rate in the literature ranges from 1% to 15%[10,25-33]. Predisposing factors could be a large empty space below the acromion and a large surface area of the prosthesis itself. Beekman *et al.* report on a 3.8% rate of infection, more often in revision shoulder surgery. The most frequently isolated agents were *Propionibacterium acnes*, coagulase negative staphylococcus and *Staphylococcus aureus*[34]. These bacteria are normal flora in the axillary fossa. Clinical signs of infection include local manifestations but with no significantly elevated inflammatory parameters. Low smoldering infection with no signs of systemic inflammation but local redness in the lower portion of the operative scar, painful movements in the shoulder joint and subsequent limited range of motion were noted in our patient series. The levels of ESR and CRP were elevated, CRP never above 30. Leukocyte level was at the upper reference limit[35]. According to literature data, infections occurring within the first year after surgery are related to skin and those appearing later are of hematogenous nature. In our experience, these assumptions are rather arbitrary since the results of microbiological analyses that could confirm them were unspecific in our patient series. In the lower portion of the operative scar, a small abscess sac appeared and after its perforation a fistula remained. Only in one female patient, infection was located in the humeral stems, which led to humeral component loosening.

In the remaining 5 cases, a typical infection site was between the plastic inlay and the inverse body and between the metallic back and the glenoid sphere. It should be mentioned that infection did not affect stability of prosthesis components. After verification of infection, we explanted the prosthesis, performed extensive debridement and thorough removal of bone cement if a cemented prosthesis type had been implanted. In one patient, a new prosthesis was implanted as one step procedure without complications. In a female patient with infection involving the prosthesis stem, only the humeral component was replaced. In another two female patients, a new prosthesis was implanted after 6 months (two step procedure).

A much greater problem than infection was dislocation of the prosthesis in the first weeks after surgery, especially in patients with revision shoulder surgery and/or posttraumatic arthritis. Dislocations occurred in the first four weeks after surgery due to a very simple reason: after removal of the diseased portion of the proximal humerus, an empty space was created between the prosthesis and deltoid muscle, which was previously filled with the tubercles and rotator cuff. The prosthesis would simply dislocate into that empty space. Heavier leaning on the elbow with the arm in maximum adduction resulted in dislocation. With time, we concluded that these patients should be differently treated (prolonged, more rigid immobilization) in the postoperative course, so that the incidence of dislocation was significantly reduced. In patients with acute injury, the lesser and greater tubercles are fixed with sutures to the body of reverse prosthesis, i.e. to the proximal part of the humeral component of the prosthesis, so the dislocation rate was lower. Spongious bone from the extirpated humeral head should always be used to augment fixation of the tubercle.

How to prevent dislocation? Firm immobilization is necessary for good healing of the lesser and greater tubercle, and this is best achieved by the thoracobrachial cast. Fixation of the upper arm to the thorax alone using Desault bandage is not sufficient. The upper arm in Desault bandage can be moved in relation to the thorax. A brace for stabilization is also not enough because it can be moved and the patient can take it off easily. The solution is a thoracobrachial plaster cast or, if the patient can pay for it, a thoracobrachial plastic cast. This cast guarantees a sufficient degree of postoperative stability. Immobilization lasted for 4-5 weeks after surgery and the upper arm was in neutral rotation with 45 degrees of abduction. During that time, fibrous tissue would grow between the prosthesis and deltoid muscle, thus preventing dislocation.

Reduction after dislocation was usually done using the open method because closed reduction is difficult and insecure. After reduction, immobilization was applied for 4-5 weeks, the same as with primary treatment.

Instability of the prosthesis is a relatively frequent complication that depends on the metal back design and quality of the bone. Its incidence ranges from 0%

to 30%[17,22-24,33,36-41]. Some authors blame the approach (deltoid-pectoral)[25,42] and the degree of retroversion of the glenosphere by more than 10 degrees[43], whereas the size of glenoid sphere does not affect prosthesis stability.

Scapular notching is a radiological finding of bone thinning in the lower portion of the scapular neck as a consequence of notching of the neck and medial portion of the humeral prosthesis component. According to relevant literature data, the incidence of notching varies from 0% to 96%[15,17,25,27,28,45]. This complication is associated with an increased incidence of glenoid component loosening[17,27,28,45]. Eccentric glenosphere also contributed to the reduced rate of notching. In the yearlong follow up of patients with regular x-rays, we did not record any notching towards the scapular neck. In our opinion, the reason for this is the design of the prosthesis we purchased through open public tender procedures. In this prosthesis type, the angle between the stem and inverse body is 130 degrees and the polyethylene inlay that produces notching does not reach the neck. This prevents creation of bone damage to the scapular neck usually visible on x-rays. On the other hand, such a design conceals the risk of dislocation of the prosthesis in the first few weeks after surgery. Notching towards the acromion was not recorded in our patients.

In cases of acute fractures, x-rays provided information on the healing of tubercles fixed to the reverse prosthesis and humeral diaphysis. Adequate mineralization of the tubercles in the lateral portion of the humeral component was the sign that the tubercles and the adjacent rotators had been successfully fixed. This ensured external rotation in abduction of the upper arm. In cases with posttraumatic arthritis where the rotator cuffs could not have been spared, the lower arm falls forward in the abducted position of the upper arm because the exterior rotators (that support the upper arm in external rotation) are missing (infraspinous muscle and teres minor muscle), the so called 'dropped arm'.

Conclusion

Reverse shoulder prosthesis is probably the most significant advance in shoulder surgery in the last two decades. As a rule, implantation of the prosthesis results in pain relief and improved function. Implantation of reverse shoulder prosthesis has been spreading fast all over the world and it replaces anatomic prosthetics. At the Clinical Department of Traumatology, Sestre milosrdnice University Hospital Center, Zagreb, Croatia, the reverse shoulder prosthesis has significantly influenced the approach to shoulder replacement surgery. In our opinion, it gives a highly experienced surgeon a solution for many pathologic conditions in the shoulder, relieves pain and restores function of the shoulder joint. In view of the fact that this is the utmost solution for shoulder joint, we may further conclude that it is mostly reserved for aged patients. The aim of rehabilitation was to restore shoulder function and prevent postoperative pains. One depends on the other, i.e. the lesser the pain, the better the function. The most significant issue for both the patient and the physician is to restore the range of motion as much as possible with as less pains as possible. The analysis of physical therapy outcomes showed that satisfactory results were obtained after 7 months on the average and in this period a satisfactory range of motion and in most cases painless shoulder with mild occasional pains was achieved. Rehabilitation lasted from 5 to 12 months. Implantation of prosthesis in acute fractures results in quick recovery, pain relief and satisfactory final outcome. In patients with posttraumatic arthritis and cuff tear arthropathy, the process of rehabilitation was longer because of significant atrophy of shoulder muscles in the postoperative course, deltoid muscle in particular. The longer the period of inactivity prior to surgery, the longer was rehabilitation after the surgery with the final outcome poorer than in acute fractures. The greater the range of motion, the smaller was pain and the greater was patient satisfaction.

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Sažetak

OBRNUTA PROTEZA RAMENA: PRIMJENA I ISKUSTVO U HRVATSKOJ

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Inverzna ili obrnuta proteza ramena je implantat koji se posljednjih godina sve češće ugrađuje na mjesto ramenog zgloba. Ima širok spektar indikacija, od višeivernih prijeloma humerusa, posttraumatskih artroza pa do artroza uzrokovanih gubitkom rotatorne manžete. U našoj Klinici ugrađuje se od 2004. godine, isprva sporadično, a potom sve više. Tijekom idućih 8 godina ugrađeno je preko 250 ovih proteza. U to nisu uključene proteze koje su ugrađene u drugim bolničkim ustanovama, ali pod vodstvom stručnjaka iz naše ustanove. U poslijeoperacijskom tijeku, prvih 4-6 tjedana, bolesnik je bio imobiliziran, najčešće torakobrahijalnim gipsom. Nakon skidanja imoblizacije uslijedila bi fizikalna terapija. Dužina fizikalna terapije ovisila je o mnogo čimbenika. U pravilu je duže trajala kod bolesnika koji su operirani zbog posttraumatske artroze i prijeoperacijski su imali atrofiju deltoidnog mišića i kontrakturu ramena. Od komplikacija treba spomenuti luksacije proteze u kratkom poslijeoperacijskom tijeku (prva 4 tjedna) i infekcije. Infekcija je osobit problem, a njezino liječenje uključuje i vađenje proteze.

Ključne riječi: *Rame, frakture; Rameni zglob – kirurgija; Artroplastika – metode; Hrvatska*