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Ways to prevent adverse outcomes and complications of total shoulder arthroplasty

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Background Total shoulder arthroplasty (TSA) is a well-established procedure for treatment of severe pathologies of the shoulder joint. However, it is a radical procedure that may result in adverse outcomes and complications. **The goal** was to identify causes of poor functional outcomes and complications after total shoulder replacement and search ways to prevent them. **Material and methods** Outcomes of 168 patients were reviewed. Reverse shoulder arthroplasty and cemented humeral fixation was employed for the majority of patients (n = 125; 74.4 %). Minimal follow-up was at least one year with an average term of 3 to 5 years. Clinical, biomechanical examinations, radiography, magnetic resonance imaging, computed tomography, electromyography, DEXA, VAS, ASES, UCLA, statistical analysis were employed in the study. **Results** Positive results of TSA were observed in 83.3 % of the cases and 16.7 % had poor outcomes. Patients developed implant dislocation in 9.5 %, infection in 3 %, early instability of shoulder component in 1.2 %, intraoperative fracture of the humerus shaft in 1.8 % and injury to vascular and nerve bundle in 1.2 % of the cases. Causes of poor outcomes were identified and ways of prevention presented. The best recovery was observed with anatomic shoulder replacement, integrity and functionality of the rotator cuff, absence of fatty degeneration verified with magnetic resonance imaging in sagittal plane. Clear understanding of the exact nature of osseous changes using computed tomography allows adequate positioning of implant components. Preoperative deltoid evaluation is important for posttraumatic cases as well as BMD measurements are vital for severe osteoporosis patients with application of reverse shoulder arthroplasty. **Conclusion** Preoperative planning and assessment of risk factors are important in preventing complications and improving outcomes of total shoulder replacement. The target audience is trauma and orthopaedic surgeons.

Keywords: arthroplasty, shoulder joint, adverse outcome, complication, prevention

INTRODUCTION

Posttraumatic injuries and degenerative joint diseases of the shoulder of different etiology result in marked disorders of the upper limb function [1]. Patients suffer from disabling pain, limited function of the shoulder joint, decreased muscle strength, difficulties in everyday activities and impaired health-related quality of life [2]. Treatment of the severe condition of the shoulder is challenging since the changes are unrestorable, and organ-saving techniques are often ineffective. Total shoulder arthroplasty (TSA) has become a common procedure in orthopaedic practice [3] providing pain relief and improved function for the majority of patients. However, joint replacement is a radical procedure that may result in adverse outcomes and complications. Overall reported complication rates after primary TSA vary from 7.5 % [4], 9.5 % [5] to 13–49 % [6] and the adverse effects include neuropathy of long branches of the brachial plexus [7], intraoperative fractures and dislocations, infections, etc. [8]. Patients with hypotrophic muscles at the area of the involved joint, rotator cuff injury, bone defects as well as patients with malpositioned implant, inadequate rehabilitation are at high risk for poor functional outcome and complications.

The goal of the study was to identify causes of poor functional outcomes and complications after total shoulder replacement and search ways to prevent them.

MATERIAL AND METHODS

Outcomes of 168 patients with injuries and diseases of the shoulder joint treated with TSA between 2008 and 2017 were reviewed. There were 95 (56.5 %) female and 73 (43.5 %) male patients. The mean age was 65 years (range, 26-81 years). Comprehensive preoperative evaluation including medical records, clinical and biomechanical examinations, radiography, US and MRI revealed arthrosis grade III (n = 40), secondary arthrosis grade III (n = 8), malunited fracture of the proximal humerus (n = 97), nonunion of the surgical neck of the humerus and delayed fracture dislocation (n = 19), avascular necrosis of

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the humeral head (n = 4). The choice of implant was based on a pattern of shoulder pathology: unipolar arthroplasty and cemented fixation (n = 19), total anatomic arthroplasty and cemented stem fixation (n = 11), total anatomic arthroplasty and uncemented stem fixation (n = 8), total anatomic arthroplasty and uncemented proximal fixation of short stem (n = 5). Reverse TSA and cemented fixation of the humeral stem was used in the majority of the cases (n = 125; 74.4 %). Minimal follow-up was at least one year with an average term of 3 to 5 years.

VAS scale was employed to assess pain intensity. A standard angular gauge was used to measure shoulder abduction and flexion. Spring hand dynamometer was used to measure shoulder abduction and flexion strength (kg). ASES and UCLA scales were applied to evaluate function of the involved joint compared to the contralateral joint. Range of motion was measured according to recommendations of the European Society for Shoulder and Elbow Surgery (ESSES) with the patient sitting on a chair, with weight even distributed between the ischial tuberosities [9]. Functional result was assessed as poor with ASES score being less than 40, UCLA less than 11, flexion and abduction of less than 60 degrees and absence of external rotation. Radiographic evaluation with anteroposterior and lateral views of the involved joint was performed for all patients. Computed tomography was indicated to identify bone defects. MRI was produced to determine integrity and functionality of the rotator cuff and fatty degeneration of muscles. Electrophysiological studies were performed for 56 patients using a four-channel Nicolet Viking IV electromyography and EP (Nicolet Biomedical, USA). EMG findings of the intact limb were used as controls. Mineral bone density (BMD) was measured in 38 cases using dual-energy X-ray absorptiometry with Lunar DPX–NT bone densitometer. Excel worksheets were used for statistical data analysis. Statistical processing was performed with parametric Student's t-test and non-parametric Wilcoxon-Mann-Whitney test.

RESULTS AND DISCUSSION

Result of treatment was evaluated in all the patients at a minimum of one year postsurgery. Most of the patients (n = 140; 83.3 %) were satisfied with TSA outcome and reported pain arrest, increased range of motion and improved function of the limb. ASES scores improved from 36.2 ± 8.5 to 78.5 ± 6.9. The mean UCLA shoulder rating score was 21.3 ± 5.9 with a maximum score of 35. And 18 patients ticked 'not satisfied' with the outcome. Poor functional result was revealed in 28 patients (16.7 %).

Implant dislocation was a common complication (n = 16). Other adverse effects included infection (n = 5), early instability of the humeral component (n = 2), intraoperative fracture of the humeral shaft (n = 3) and injury to vascular and nerve bundle (n = 2).

Literature analysis shows more convincing results of survival of anatomically implanted shoulder arthroplasty as compared to those observed with reverse arthroplasty [10]. We tried to use the anatomic implant in the cases when it was possible. Intact rotator cuff was essential for application of anatomic shoulder arthroplasty.

MRI was indicated for patients with either degenerative joint disease of the shoulder or avascular necrosis for careful preoperative evaluation to consider placement of anatomic endoprosthesis. Functionality of the rotator cuff, i.e. absence of fatty degeneration of rotator cuff muscles was another factor that was recognized preoperatively in addition to anatomically intact rotator cuff. It should be noted that fatty degeneration of the supraspinatus and infraspinatus muscles could be identified on sagittal MRI images only (Fig. 1). For instance, anteroposterior MRI of the shoulder of a 64-year-old patient M. showed intact rotator cuff (Fig. 1a, arrows) and sagittal MRI image indicated to marked fatty degeneration of the supraspinatus (Fig. 1b, asterisk) and infraspinatus (Fig. 1b, arrows) muscles. The identified dysfunctionality of the rotator cuff was a contraindication to anatomic endoprosthesis.

Implantation of anatomic endoprosthesis requires accurate surgical technique. Functional strength of the rotator cuff following arthroplasty is provided by adequate positioning of the stem of anatomic humeral prosthesis and balance of soft tissues. The humeral component placed too high can cause excessive compression of the supraspinatus tendon in the subacromial space and its mechanical injury.

The humeral component placed too low can result in impingement of the greater tuberosity of the humerus and acromion process of scapula.

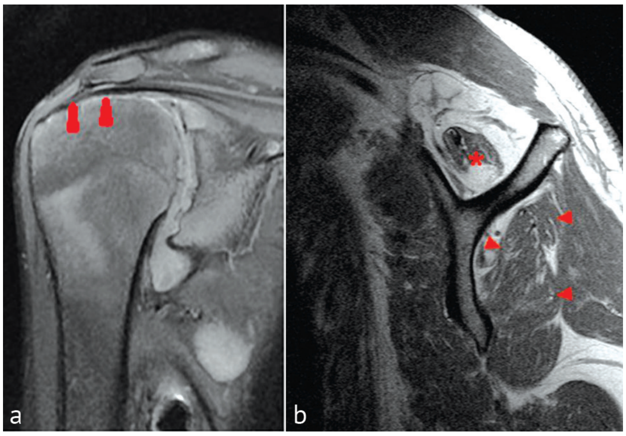

Fig. 1 MRI images of the shoulder joint of a 64-year-old patient M. showing ***a*** anteroposterior ***b*** sagittal views

Bone defects of articular process of scapula of different severity were observed in 48 % of patients. Analysis of preoperative planning revealed the importance of CT evaluation of the involved joint because conventional radiography could not provide full understanding of the nature of bone changes. Bone defect of the articular process of scapula was likely to be neglected and might result in misplacement of glenoid component. Figure 2 demonstrates the case when compared with standard anteroposterior radiograph (Fig.2a) axial view of CT scan (Fig. 2b) of the same patient revealed marked bone defect due to wear and tear of the posterior portion of the articular process of scapula. We believe that CT evaluation is a must for all cases of degenerative shoulder joint disease and complicated posttraumatic deformities of the proximal humerus.

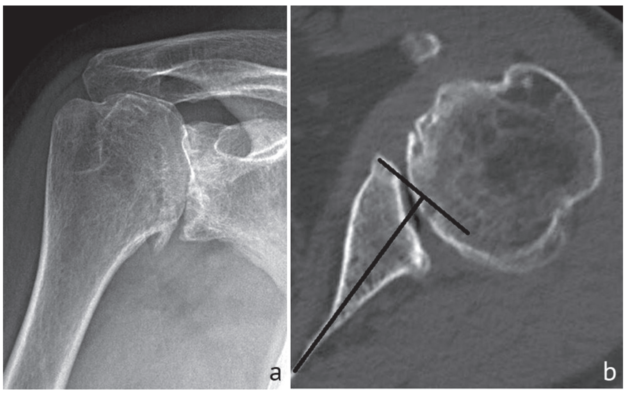

Fig. 2 Images of the shoulder joint: ***a*** standard anteroposterior radiograph; ***b*** axial CT scan of the same shoulder joint

Good function of deltoid muscle and intact short external rotators are a prerequisite for normal functioning of reverse endoprosthesis [11]. Deltoid upward traction provides stability in the joint with reverse prosthesis in place. Functioning of short external rotators (infraspinatus and teres minor muscles) prevent anterior displacement of the humeral component of the reverse implant. Absence of short external rotators was detected intraoperatively in 34 cases (Fig. 3).

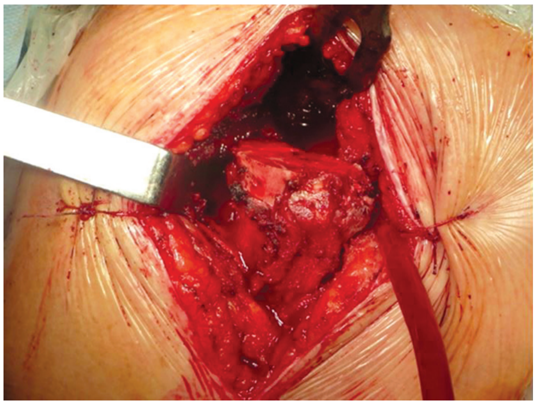

Fig. 3 Intraoperative photograph showing absence of infraspinatus and teres minor muscles

Functionality of deltoid muscle was evaluated with EMG performed for 56 patients. There were no statistically significant differences in electromyographic parameters of patients with degenerative shoulder or patients with aseptic necrosis of the humeral head (n = 8) compared with contralateral limb. Decreased EMG values were observed only in patients with posttraumatic articular changes (n = 48) with 13 cases having decrease in M-response of more than 2.2 mV in deltoid muscle. Nine patients of the group developed instability and dislocation of prosthesis (69 %). Decrease in M-response ranged from 2.5 to 5.8 mV in 23 cases. Dislocation of endoprosthesis was observed in 5 patients (21.7 %) of the group. All dislocations of the reverse endoprosthesis occurred in patients with weak deltoid muscle and absence of short external rotators of the shoulder (Fig. 4). So, for example, baseline EMG evaluation showed hypotrophic deltoid muscle and low bioelectric potential with M-response of 2.0 mV recorded in a 73-year-old patient Sh. who developed dislocation of the reverse endoprosthesis 4 days postsurgery.

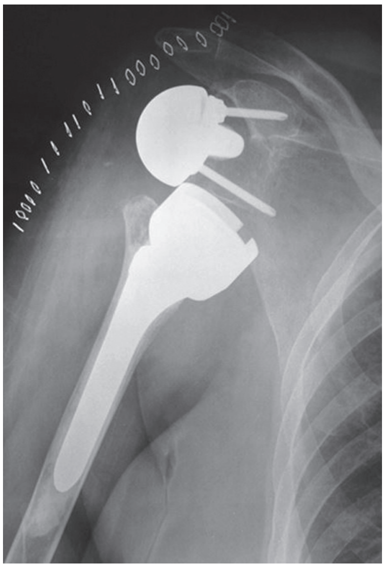

Fig. 4 Radiograph demonstrating dislocation of the reverse endoprosthesis of the shoulder

Anterior displacement of the proximal humerus was also caused by deltoid traction with absent antagonists – short external rotators of the shoulder. Therefore, EMG examination should be indicated to all patients with posttraumatic condition of the proximal humerus. Reverse TSA could not be advocated for patients with decreased M-response of less than 2.5 mV from deltoid muscle (or less than 40 % of the contralateral limb) due to an unreasonably high risk of prosthesis dislocation. Reconstruction of external rotators of the shoulder could be considered in patients with normal deltoid muscle [12]. There was a possibility with direct re-fixation of infraspinatus and teres minor muscle tendons to the proximal shaft of the humerus in cases when TSA was indicated for nonunion of the surgical neck of the humerus. External rotator tendons appeared to be retracted and rigid in the rest of the cases with posttraumatic deformities of the proximal humerus and could be fixed to the bone using tendon grafts. Transposition of the latissimus dorsi muscle was a method of choice [13].

The strength of glenoid component fixation was the ‘weakest’ point of reverse shoulder arthroplasty [14]. Densitometry assessment showed greater decrease in BMD in patients with nonunion of the surgical neck of the humerus. Early instability of glenoid component was observed in 2 patients with severe osteoporosis. Figure 5 demonstrates a case of severe osteoporosis with T-score 2, 1SD detected with DEXA (Fig. 5a) and instability of glenoid component detected 4 days postsurgery (Fig. 5b).

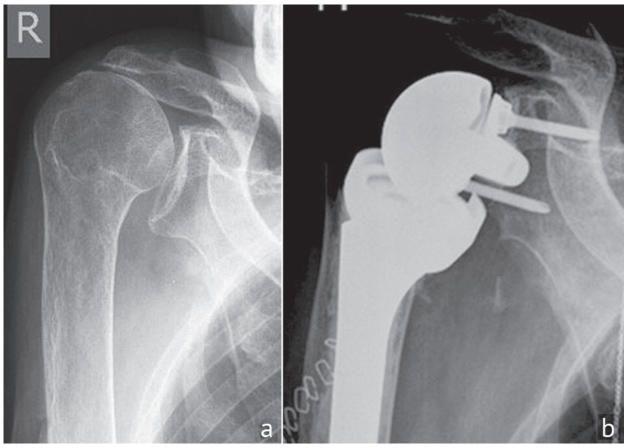

Fig. 5 Radiographs of the shoulder joint of patient A.: ***a*** prior to TSA; ***b*** 4 days postsurgery

Intraoperative fracture of the humerus shaft (n = 3) occurred as a complication due to extremely aggressive rasping of the intramedullary canal of the humerus. Posttraumatic bone obliteration of the proximal diaphysis of the humerus was observed in all cases and resulted in fractures at reaming and rasping that were stabilized with cerclage wiring. All cases of vascular and nerve injures were seen in patients with old fracture dislocations of the proximal humerus with a free fragment of the humeral head located in subcoracoid area. Direct injury to the radial nerve (n = 1) and to the anterior circumflex humeral artery with considerable bleeding (n = 1) occurred with removal of the humeral head fragment. Hemostatic clamps applied to soft tissues caused compression of brachial plexus rami that led to brachial plexopathy. Special accuracy is needed with manipulations in subcoracoid space, and random placement of hemostatic clamp to be avoided in bleeding. Infection (n = 5) was seen in all patients who had undergone plating of the proximal humerus prior to TSA. Preoperative microbiological examination of paraarticular tissues and synovium, quantitative evaluation of C-reactive protein, thorough preoperative skin preparation, appropriate selection of antibiotics are recommended for prevention of surgical site infection in shoulder surgery like in any joint replacement procedure.

Therefore, TSA is an effective procedure for treating patients with severe irreversible pathology of the shoulder joint. Patients report pain relief, increased range of motion in the shoulder, improved function of the upper limb and activities of daily living. However, strictly selected patient population and adequate choice of implant are critical for successful outcome.

CONCLUSION

Functionality of intact rotator cuff of the shoulder and absence of fatty degeneration are important for anatomic TSA. Functionality of the rotator cuff after TSA is provided by adequate positioning of the stem of anatomic endoprosthesis and balanced soft tissues.

Nearly half of the patients had bone articular defects of different severity. Clear understanding of the exact nature of osseous changes using computed tomography allows adequate positioning of implant components.

Most complicated cases of TSA were seen in patients with posttraumatic articular changes with no possibility to restore integrity of the rotator cuff of the shoulder. These patients were treated with reverse TSA. Good condition of deltoid muscle (EMG 80 % of the contralateral limb and over) is vital for proper endoprosthesis functioning, otherwise postoperative period could be complicated with dislocation and unstable implant. Patients with EMG findings between 40 and 80 % of the contralateral limb require a 6-week immobilization of the operated extremity and electric stimulation of the deltoid muscle to improve the tone. Augmentation, myotranspositon techniques can be considered to address absence of short external rotators of the shoulder. Reverse TSA cannot be advocated for patients with severe osteoporosis with T-score less than 2.5 SD. Preoperative planning and assessment of risk factors are important in preventing complications and improving outcomes of total shoulder replacement.

Conflict of interests*. Authors declare no conflict of interests.*

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