

Periprosthetic Humeral Fractures after Shoulder and Elbow Arthroplasty

Periprotetické zlomeniny humeru po aloplastice ramena a lokte

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SUMMARY

Due to rapidly increasing numbers of arthroplasty surgeries of the upper extremity, periprosthetic humeral fractures after shoulder and elbow arthroplasty, formerly described as rare, may hence increase in the near future. Therefore the aim of the present work was to give an overview of the existing literature including possible classifications as well as an update on treatment concepts and experiences with own cases.

After a literature research have been done, existing prevalence, classifications and treatment options, mostly described in case series, were processed to create an overview of the existing state of knowledge. Additionally 7 own cases are described in detail to show the different treatment options used at the authors department.

The currently used classification systems take fracture location, angulation and rotation and fixation of the implant into account. Possible solutions for periprosthetic fractures of the humerus include conservative management, open reduction and internal fixation for stable prosthesis and long stemmed implants for loose implants as well as the use of additional allo- or autogenous bone grafting and reverse shoulder arthroplasty in revision cases with rotator cuff dysfunction. After all treatment of periprosthetic humeral fractures after shoulder and elbow arthroplasty remain a challenging problem.

Key words: periprosthetic fracture, shoulder arthroplasty, elbow arthroplasty, classification, treatment options.

INTRODUCTION

Despite raising numbers of shoulder and elbow prostheses implanted, reports of treatment of postoperative periprosthetic fractures of the humerus after shoulder and elbow arthroplasty are rare. According to the literature the prevalence of periprosthetic humeral fractures after shoulder arthroplasty accounts about 1.6 to 2.4% (4, 27). However, a literature research reveals that there are less than 40 cases described with a majority of case reports and small case series. Due to the fact that implantation numbers of total elbow prostheses are inferior to those of shoulder prosthesis, descriptions of periprosthetic humeral fractures after elbow arthroplasty are even rarer. Although prevalence of periprosthetic humeral fractures after total elbow arthroplasty has been described to be about 5% (21), their clinical and radiographical appearance and treatment options have also been rarely discussed in the literature with one case series of

11 patients (22) and 4 case reports (14, 16, 17). However, discussion of treatment options for both entities, humeral fractures after shoulder or elbow prostheses is relevant since non – operative treatment may lead to a high failure rate and operative treatment is challenging. This is especially true since large bone defects and osteoporosis are frequently present in these cases (15, 22). Kamineni, 2004, Proximal ulnar reconstruction with strut allograft in revision total elbow arthroplasty. Sanchez-Sotelo, 2002, Periprosthetic humeral fractures after total elbow arthroplasty: treatment with implant revision and strut allograft augmentation. (6, 12, 21)

According to fracture location and patterns, bone quality and defects, a potential acute or preexisting loosening of the components, different treatment methods have been described. Moreover, preoperative function and integrity of the rotator cuff in shoulder arthroplasty should be taken into account in decision-making.

Aim of the present work is to update treatment concepts of these problems according to the current literature and experiences with own cases.

Mechanism of injury

There are a variety of causes that may lead to a post-operative periprosthetic fracture of the humerus. Fractures occur mainly because of a fall on the outstretched operated extremity (4, 27). However, cortical weakening due to prosthetic loosening, severe bone loss or osteoporosis may also lead to a periprosthetic humeral fractures without adequate trauma (18, 28). In their series of 16 patients with postoperative periprosthetic fractures after shoulder replacement Kumar et al. reported on 3 patients without an adequate trauma in their history, whereas 13 patients had a fall or accident (18).

Regarding periprosthetic fractures adjacent to elbow prostheses weakening fractures are far more common. Sanchez-Sotelo et al. report on 10 patients with post-operative humeral fractures after elbow arthroplasties. Out of these patients, 5 had a spontaneous fracture without adequate trauma (22).

Classification

There are different classification systems described for periprosthetic fractures after shoulder arthroplasty. In one of the first presentations of a case series of periprosthetic humeral fractures, fracture patterns were differentiated in spiral, oblique and transverse (4). Wrieth and Cofield introduced the first classification system regarding this entity (28). Fractures are classified into 3 different types (A, B, C) according to the fracture location in relation to the stem of the prosthesis. A type – A fracture is centered at the tip of the prosthesis with an extension of more than one-third of the length of the stem. Type – B fractures are also centered at the tip but extension is less than one-third of the length of the stem. And type – C fractures are distal of the tip of the prosthesis with extension in the distal humeral metaphysis. Moreover fracture angulation and displacement is taken into account and is classified in none, mild (less than 15° of angulation, or less than 1/3 displacement of the shaft diameter), moderate (16–30° of angulation or 1/3–2/3 fracture displacement of the shaft diameter) and severe (more than 30° of angulation, and more than 2/3 displacement of the shaft diameter) (28).

Worland et al. published 1999 a new classification also accounting for implant stability. Moreover according to this classification system a treatment recommendation can be given (Tab. 1).

Regarding humeral fractures after total elbow replacement, the Mayo group established a classification system taking into account fracture location, bone stock and loosening of the prosthetic stem (Tab. 2).

The authors also give a treatment recommendation regarding their classification system: Type H-I usually do not require surgical treatment. In contrast, type H-II fractures almost always need to be treated surgically, especially if osteolysis or loosening of the component is present. The need of surgical treatment in Type H-III

Tab. 1

Classification	Description	Treatment recommendation
Type A	Fracture about tuberosities	Conservative or ORIF
Type B	Fracture around the stem	
B1	Spiral fracture, stable stem	Conservative or ORIF
B2	Transverse or short oblique fracture, stable stem	Revision with long stem
B3	Unstable stem	Revision with long stem
Type C	Fracture well distal to the stem	Conservative or ORIF

Tab. 2

Fracture type	Description
H-I	Fracture of the column or condyles
H-II	Fracture around the stem
H-II1	Implant well fixed
H-II2	Implant loose with acceptable bone stock
H-II3	Implant loose with severe bone loss
H-III	Fracture proximal to the stem

depends on fracture stability and dislocation and on implant stability (22).

Diagnostics

Clinical and radiographic diagnostics are focused on fracture location in relation to the component, whether the stem of the prosthesis is well fixed or not and whether the fracture is stable or not.

A careful clinical exam is mandatory with respect on the neuro-vascular status, soft tissue swelling and clinical monitoring of absence of developing of a compartment syndrome. Especially due to its course at the humeral shaft the radial nerve is at risk and its senso-motoric integrity has to be evaluated and documented. Moreover, in patients with shoulder prostheses, radiographs should be evaluated whether the prosthetic head is centered and preoperative rotator cuff function should be carefully evaluated in anamnesis. This holds especially true in patients having obtained hemiarthroplasty for proximal humeral fractures since malunion or non-union of the tuberosities may be a preexistent problem.

Usually conventional radiographs of the implant (shoulder prosthesis: true a/p and y view; elbow prosthesis: a/p and lateral view) and the humeral shaft in 2 planes are sufficient for treatment decision. However, especially if severe bone loss is present, CT Scan analysis may add additional information about the remaining bone stock.

Moreover, CT Scan analysis is helpful in evaluating glenoid bone stock or glenoid component integrity after hemi or total shoulder arthroplasty. This is important since concomitant problems with the glenoid must be taken into account if revision surgery of the implant is planned. Moreover, surgeons should gain all available informations about the previous operation and the component.

Conservative treatment

Regarding current classification systems and treatment recommendations conservative treatment of humeral fractures after shoulder arthroplasty can be considered if the fracture is located either around the tuberosities or well distal to the stem or if it is a spiral fracture which is non-displaced or minimally displaced with a fixed stem (5, 28). Moreover, fracture alignment should be maintained in a fracture brace in a satisfactory manner (24). Kumar et al. defined satisfactory alignment as within 20° of flexion/extension and rotational alignment and 30° of varus/valgus alignment (18). However, there are reports of union of periprosthetic humeral fractures after conservative bracing, even if major displacement is present. Kim et al. reported about two cases of displaced periprosthetic humeral fractures which were treated with functional bracing. Both fractures showed complete union with marked angulation at 12 and 16 weeks respectively and both patients were able to return to their preoperative functional level (17). Patient medical condition and functional demands should be considered when making treatment decision. Type C – fractures should be treated as routine humeral shaft fractures with the corresponding implications for conservative treatment (7, 25).

In general, conservative treatment of periprosthetic humeral fractures has high failure rates. Boyd et al. treated all of the 6 investigated patients primarily conservatively with just one successful healing (4). Worland et al. reported about 1 successful (Type C) and one failed non operative treatment (Type B3) (27). Wright and Cofield described in their series 9 fractures of which 8 were initially treated conservatively. Four of them healed uneventfully and two of them had to be revised in the early treatment phase due to development of radial nerve palsy, 3 of them failed to unite and had to be surgically revised (28).

Kumar et al. account of 11 fractures treated primarily conservatively of which 6 healed successfully (3 type A, one type B, two type C – fractures). Five fractures failed to unite and were operatively stabilized (one type A and 4 type B – fractures). Due to their experiences the authors do not recommend operative treatment for type A fractures according to Worland et al. if the implant is fixed and suggest a trial of non-operative treatment in type C fractures (18).

There is little evidence in the literature that periprosthetic humeral fractures after total elbow arthroplasty around the shaft may be successfully treated conservatively Sanchez-Sotelo, 2002, Periprosthetic humeral fractures after total elbow arthroplasty: treatment with implant revision and strut allograft augmentation. (16, 22). Just periarticular fractures of the epicondyles, which may often be due to heavy use of the involved muscles or a stress fracture from weak bone should be treated conservatively. Due to the limited amount of bone, fixation is difficult and they rarely cause clinical symptoms although non-union rate is high (22). Corresponding to C- fractures of the humerus after shoulder arthroplasty, fractures of the humeral shaft

beyond the tip of the humeral elbow component can be treated with the same implications for conservative management like immobilization and functional bracing reported for humeral shaft fractures (19). The majority of postoperative fractures are however B1, B2 and B3 fractures which should be treated operatively since they are unlikely to unite and especially a loose stem may cause further problems with ongoing endosteal erosion (21, 22).

Operative treatment

There are different treatment options described in literature for periprosthetic humeral fractures. The main goal remains fracture union, maintenance of glenohumeral or humeroulnar motion and restoration of joint function.

Most important considerations for operative treatment are among patients general medical condition and functional demands, fracture location, displacement, component fixation, bone loss, glenoid bone stock or glenoid component integrity and rotator cuff integrity and preoperative cuff function. Moreover, surgical treatment is recommended for patients with unstable fractures that have not healed after 3 months of nonsurgical treatment (18, 24). Implant stability is critical for decision making and should be carefully evaluated. Traumatic loosening can occur in some type A fractures with long, oblique fracture lines and if the fracture line extends along much of the length of the prosthesis. Preexistent component loosening can be estimated radiographically by radiolucent lines in three or more zones around the stem or change of positioning of the stem in serial radiographs if available (23). In case of humeral loosening it is recommended to revise the prosthesis with a long stemmed implant. The length of the stem should be chosen to be able to bridge the fracture and the tip of the prosthesis should extend at least three cortical diameters beyond the most distal fracture site (5). Several authors have published data about this method with considerable results (4, 18, 27) .

If revision of the implant is planned, implant design should be chosen according to rotator cuff function and glenoid bone stock or component integrity. Especially in patients having previously sustained hemiarthroplasty for proximal humeral fractures tuberosity malpositioning and migration with resulting rotator cuff dysfunction is often present (2, 9, 13).

Several authors account of indications and clinical results of reverse shoulder prosthesis in revision arthroplasty (1, 3, 8, 10). In case of preserved glenoid bone stock, revision to reversed shoulder arthroplasty in periprosthetic humeral fractures after shoulder arthroplasty with preexistent rotator cuff dysfunction is able to not only restore but even improve shoulder function. So far, reports about this intervention are not available in current literature. Two cases treated with this option are presented in the present work.

In unstable fractures with stable stems, open reduction and internal fixation can be performed. Different methods are available, e.g. cerclage fixation, screw fixa-

tion or plating. Wright and Cofield treated one type C and one type B fracture with cerclage wires with and without additional screw fixation, of which just the type C fracture united (28). Worland et al. treated one of 6 patients with a B1 fracture with cerclage fixation and union was achieved after 3 months (27).

Especially the possibility of angular stable plating with internal fixateurs can provide excellent results, because of the possibility of monocortical fixation in the region of the stem. Additional cerclage fixation around the plate and the humeral shaft can be performed and anatomic reduction and stability of the fracture side may be achieved thereby. Kumar et al. treated 3 patients, all with type B-fractures and stable stems in their series by open reduction and internal fixation with considerable results (18). Independently of the use of ORIF or a long stem, due to the frequently present poor bone quality, reduced endosteal blood supply and cortical defects, several authors report about additional iliac crest bone grafting or allograft augmentation by strut grafts to improve healing (4, 18, 27, 28).

In periprosthetic humeral fractures after total elbow replacement O'Driscoll et al. recommended conservative treatment for periarticular condyle fractures (type H-A fractures), ORIF for fractures of the shaft located around or at the tip of the stem with stable humeral component (type H-B1) and revision to a long stemmed humeral component if the stem is loose (type H-B2 and B3) (21). However, there is still little information in the literature regarding these complex cases.

Hanyu et al. reported about using a Mennen's plate with additional iliac crest bone grafting and union was achieved 6 months after the intervention (14).

Kawano et al. recently reported about a patient with a periprosthetic fracture after total elbow arthroplasty and conservative treatment failure. Final revision was performed using a "docking" technique, initially recommended for the treatment of periprosthetic femoral fractures (20, 26). A customized intramedullary nail, which was sleeved over the humeral component and additional autologous bone grafting was used. Union was achieved with considerable function 3 years after the operation (16).

Sanchez-Sotelo et al. reported about the largest series of periprosthetic humeral fractures after total elbow arthroplasty. Ten patients with postoperative periprosthetic fractures (all type H II 2 and 3 but one type H III) were treated successfully with implant revision and strut allograft augmentation. At the latest follow up with a mean of 7.8 years radiographs showed one graft resorption, union at the fracture site without graft remodeling in 4 cases and graft remodelling in 5 cases (22).

Case reports

Case 1

An 80-year-old woman had a Neer Monoblock Prosthesis for a 4-part proximal humeral fracture and refixation of the tuberosities with metal anchors. Thirty-two months later she fell on the outstretched arm and sustained a short oblique periprosthetic humeral fracture at

the tip of the prosthesis. According to the Worland system the fracture was classified as a B 2 fracture with a stable stem and marked angulation. Although x-rays demonstrated non-union of the tuberosities and cranial decentering of the prosthesis as a result of dysfunction of the rotator cuff, due to the stable stem and low functional patients demands, open reduction and internal fixation was performed. The operation was performed in a beach chair position. An anterior Henry approach as an extension of the previously used deltopectoral approach was used. After fracture reduction, an angular stable LCP plate with additional cerclage wires was used for stabilization. Thirty-eight months postoperatively the fracture was healed. The patient had an age and gender adjusted Constant Score of 48% with no pain but significant functional limitations. Pre and postoperative X-ray and clinical results of range of motion are shown in Fig. 1–3.

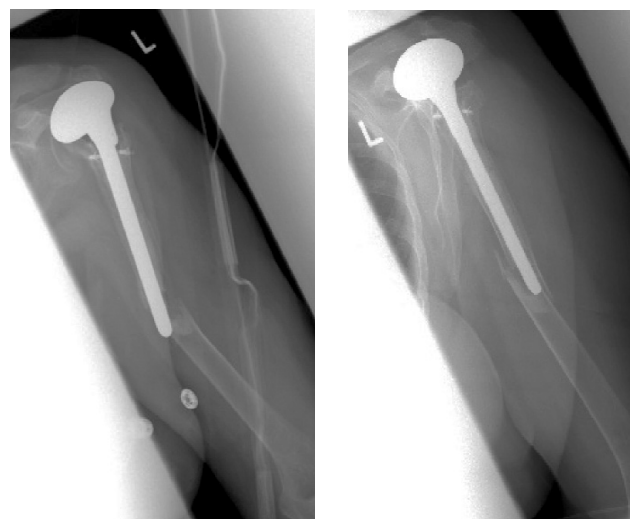


Fig. 1a–b. Periprosthetic fracture type B2 of a 80-year-old woman.

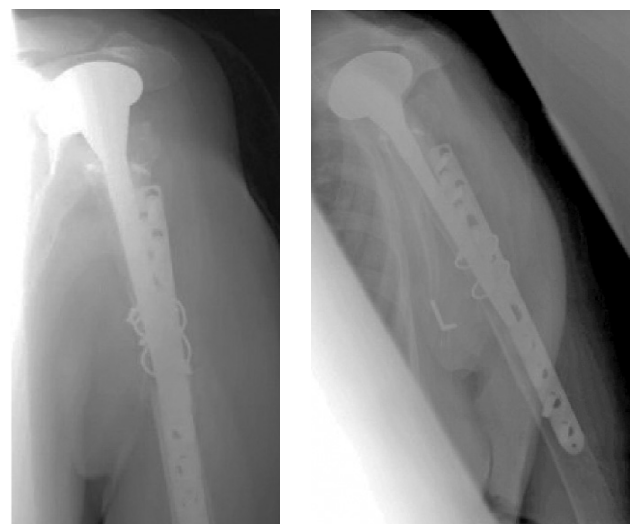
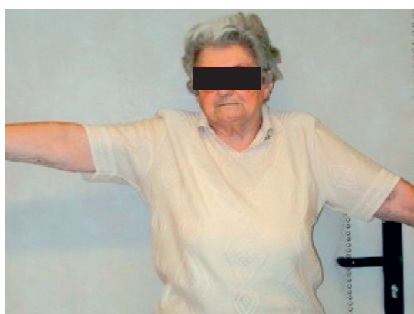


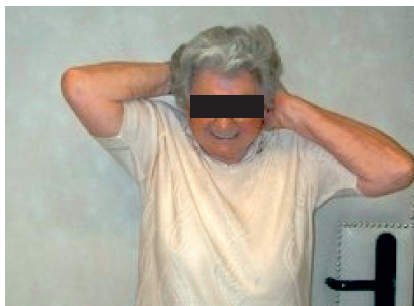
Fig. 2a–b. Radiographic result after angular stable plating and cerclage wires.



a



b



c



d

Fig. 3a-d. Functional result with an age and gender adjusted constant score of 48%.

Case 2

After implantation of a fracture prosthesis due to failed internal fixation of the right proximal humerus the 51-year-old female patient suffered from a periprosthetic fracture type B2 which was initially treated with open reduction and internal fixation in an external hospital. One year later the patient presented with a pseudarthrosis, broken internal fixation plate and loosening of the implant. Revision surgery was performed by implanting a long stemmed inverse prosthesis and revision of the pseudarthrosis by augmenting BMP and autologous spongiosa and finally bridging the pseudoarthrosis with a 9-hole-LCP fixation plate. Ten months after surgery the patient had an age and gender adapted Constant Score of 48%. Clinical results of range of motion and actual x-rays are shown in Fig. 4–6.



a



b

Fig. 4a–b. Pseudarthrosis of a type B2 periprosthetic fracture of a 51-year-old woman.

Case 3

After implantation of a hemiarthroplasty for proximal humeral fracture a 70-year-old woman had a fall on the outstretched arm. A periprosthetic humeral spiral fracture type B according to the Worland classification was diagnosed. The patient reported her preoperative function having been very poor with pain at rest and no active function above waist level. Preinjury x-rays also demonstrated tuberosity non-union and cranial migration of the prosthesis. Intraoperatively the shaft was found to be loose and could easily be extracted. Trans-humeral cement excision was performed using a pectoralis major pedicled bone window according to Gohlke et al. (11). A long stemmed reversed shoulder arthroplasty was implanted and the fracture and the cortical window were stabilized using titanium band cerclage. Eighteen months after the revision operation the



a



b

Fig. 5a-b. Radiographs after revision arthroplasty, angular stable plate fixation of the fracture and BMP and autologous spongiosa augmentation of the fracture side.



a

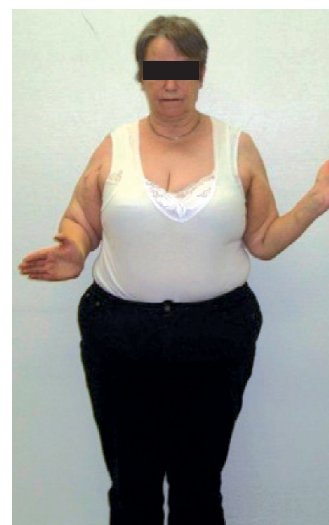


b

Fig 6a-d. Functional result with a mean age and gender adjusted constant score of 48%.



c



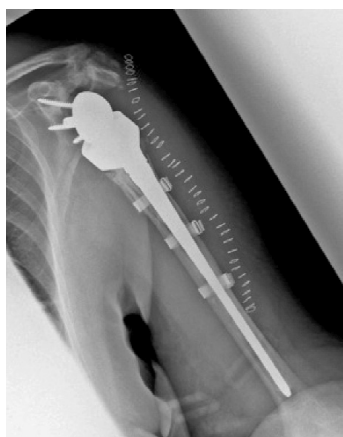
d



Fig 7. Periprosthetic fracture type B3 with decentration of the humeral head.



Fig. 9. 18 month postoperatively: healing of the fracture and the cortical window.



a



b

Fig. 8a-b. Postoperative fracture reduction and fixation.

patient showed marked improvement of the preinjury shoulder function with an age and gender adapted Constant Score of 70%, no pain and a reasonable shoulder function. X-rays showed the fracture to be healed, however important spurting and heterotopic bone formation was present at the inferior border of the scapular neck. Radiographic and functional results are shown in Fig 7–10.

Case 4

A 62-year-old women presented initially due to a chronic infection of the left shoulder 16 months after suffering a bilateral four-part fracture of the humeral head treated with fracture prostheses. The infected prosthesis was planned to be changed to an inverse prosthesis in a two step procedure. While being treated with the temporary cement spacer on the left side the patient

presented again with aseptic loosening of the fracture prosthesis and a periprosthetic fracture Type B3 (27) on the contralateral side. The preoperative function was very poor on this side due to non-union of the greater and lesser tuberosity. Surgery was performed with the patient in a beach-chair position using a deltopectoral approach. The prosthesis could be easily extracted. The remaining cement could also be removed. A long stemmed inverse prosthesis was implanted. Two months later the left side was revised using the same prosthesis. The clinical follow up 14 (right) and 12 (left) months after surgery showed good results with an age and gender adapted Constant Score of 77% (left) and 64% (right). The active range of motion is shown in Fig. 11–13.

Case 5

A 82-year-old woman suffered from a periprosthetic fracture type B3 with important bone loss 10 years after hemiarthroplasty for proximal humeral fracture. The operation was performed in a beach chair position using an extended deltopectoral approach. The radial nerve was identified and protected. The prosthesis showed to be loose and could be easily extracted. Also the cement showed to be loose and could be extracted without bone fenestration through the fracture. Intraoperatively multiple tissue biopsies were sent for microbiologic testing. Tuberosities and the belonging rotator cuff could not be identified intraoperatively. However, most likely due to recurrent anterosuperior

instability of the implant, the glenoid bone stock was very poor, which made fixation of a glenosphere base plate for an inverse design impossible. Therefore, the fracture was stabilized and a long stemmed prosthesis with a CTA Head was implanted. Due to the poor bone stock, additional augmentation with a femoral strut graft and a 3.5 angular stable plate was performed. So far, the patient is doing well with no pain but important limitation of the shoulder function. Radiographs and intraoperative findings are shown in Fig 14–17.

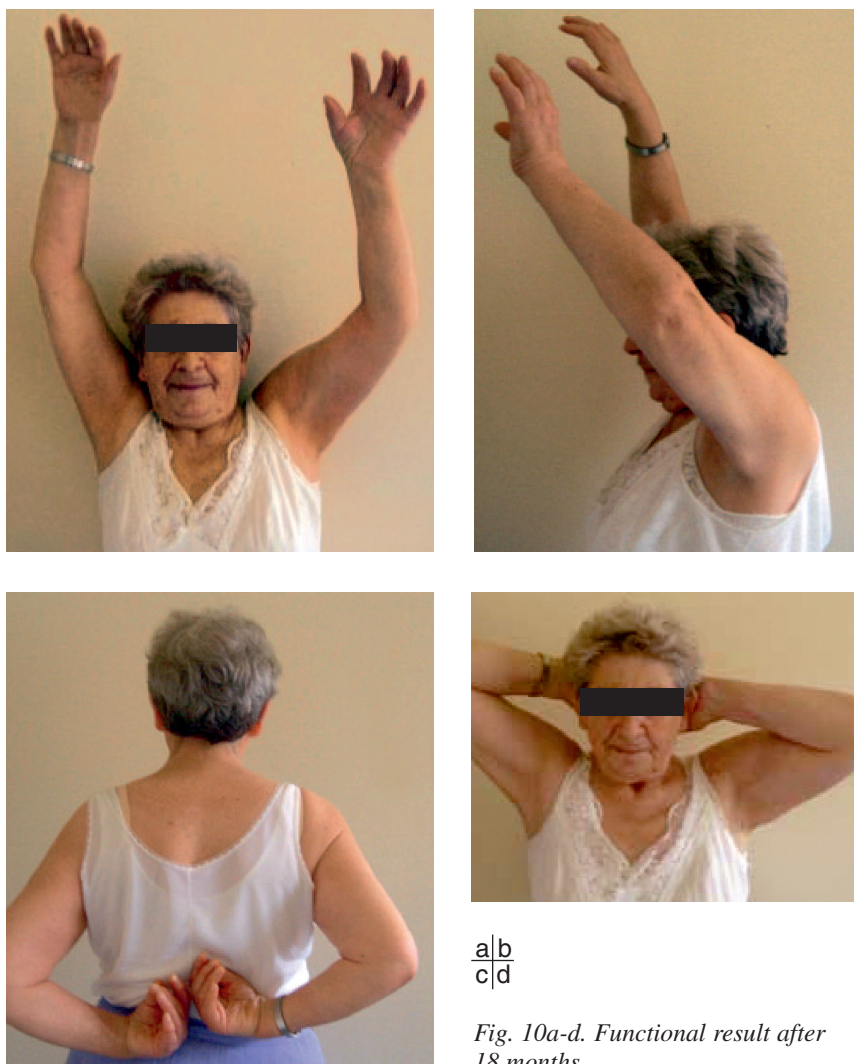


Fig. 10a-d. Functional result after 18 months.

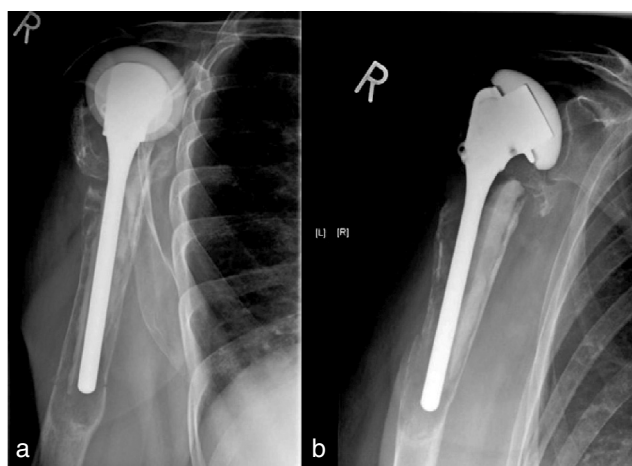


Fig. 11a-b. Periprosthetic fracture with prosthetic loosening, type B3.

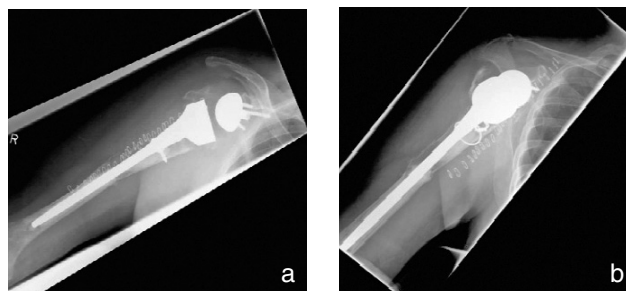


Fig. 12a-b. Radiographs after revision to a reversed prosthesis.



Fig. 13a–d. Functional result after 14 months with an age and gender adapted Constant Score of 64%.

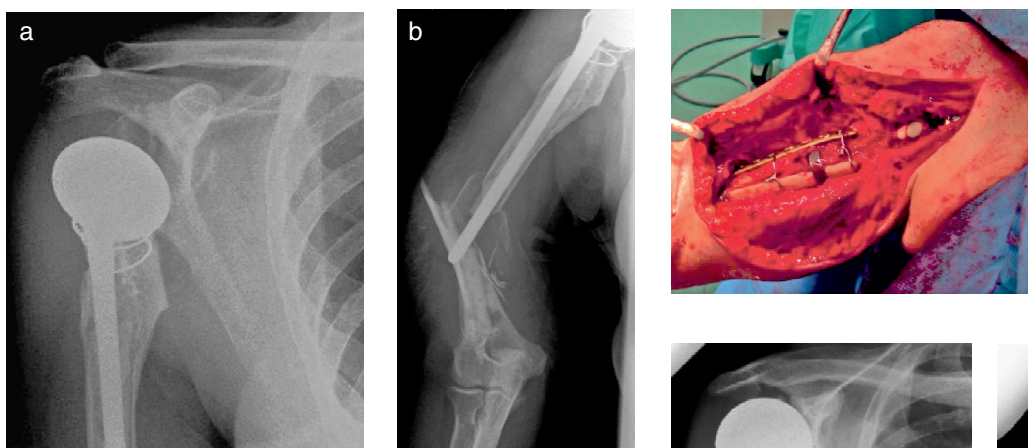


Fig. 14a–b. Periprosthetic fracture type B3.

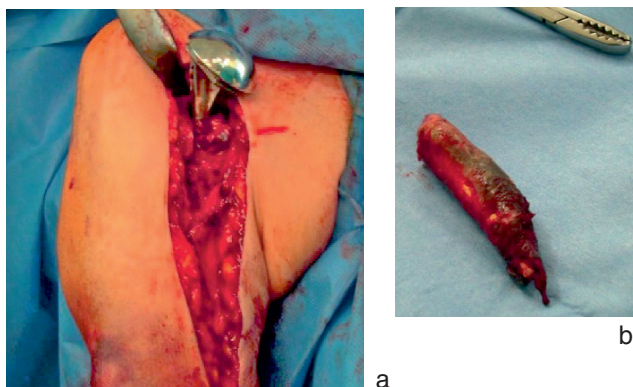


Fig. 15a–b. Intraoperatively the prosthesis and the cement showed to be loose.

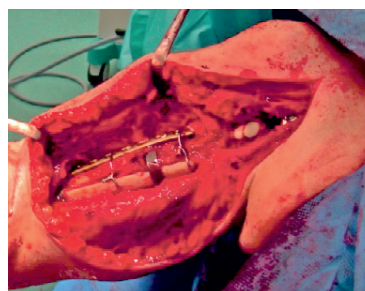


Fig. 16. Fracture reduction is maintained by long stemmed prosthesis, angular stable plating and additional strut graft augmentation.

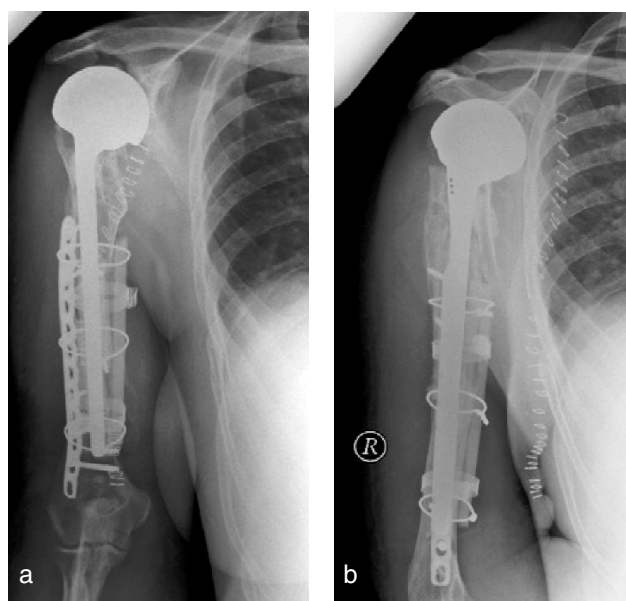
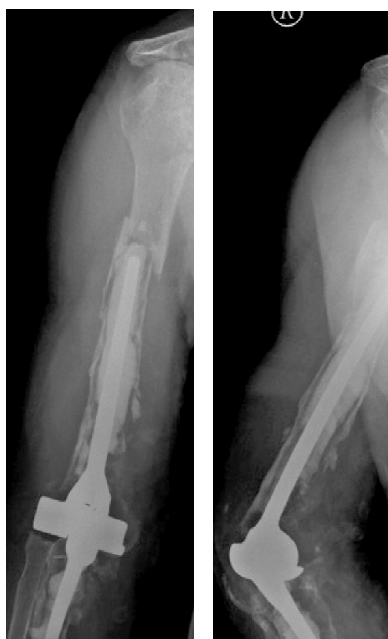


Fig. 17a–b. Initial radiographic result after long stemmed revision arthroplasty with CTA Head, strut grafting and angular stable plating.

Case 6

A 78-year-old patient having undergone total elbow replacement 10 years ago for rheumatoid arthritis reported about a crack in the upper arm with pain and immediate loss of function while lifting a 5 kg weight. X-ray films showed a periprosthetic humeral fracture at the tip of the prosthesis type H III with severe bone loss. Operation was performed in a beach chair position. An extended deltopectoral approach was used and the proximal humerus and the fracture was exposed. The radial nerve was palpated and protected throughout the

surgery. An eight-hole Philos long plate (Synthes) with an additional strut allograft was used to stabilize the fracture. One titanium band cerclage was used to additionally stabilize the plate and the bone and 5 cerclage wires were pulled around the shaft, the plate and the graft. Eighteen months after the initial operation x-rays showed no evidence bone healing nor graft remodelling while fracture reduction was maintained. The patient was pain free and had an arc of motion of 100° (Fig. 18, 19, 20).



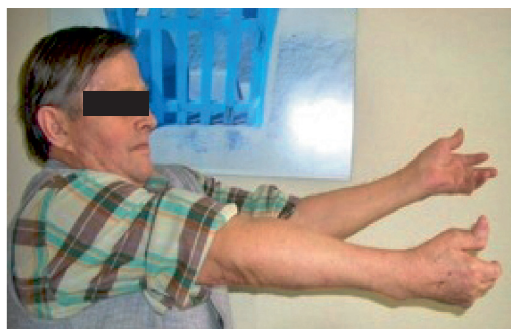
a | b

Fig. 18a–b. Peri-prosthetic fracture after total elbow arthroplasty type H III.



a | b

Fig. 19a–b. Post-operative radiograph after fracture reduction, strut graft and cerclage augmentation and angular stable plating.



a |
b | c | d

Fig. 20a–d. Clinical result after 18 months.



Case 7

An 81-year-old woman presented 5 months after two stage implantation of a total elbow arthroplasty for post-traumatic septic arthritis with pain and loss of function after having started strengthening exercises. X-ray films showed a periprosthetic elbow fracture type H A with



Fig. 21a–b. Periprosthetic fracture non-union type H-A, 6 months after the fracture.

fracture of the ulnar epicondyle. Treatment was conservative with assisted mobilization without restriction of range of motion. At 6 months x-rays showed non-union of the epicondyle but the patient had no pain and a functional arc of motion of 110° with free forearm rotation (Fig. 21, 22).

CONCLUSION

Periprosthetic humeral fractures after shoulder and elbow arthroplasty represent a challenging problem. Conservative treatment options are limited and restricted to special fracture configurations. Current classification systems take fracture location, angulation and rotation and fixation of the implant into account. If the component is stable open reduction and internal fixation can be performed. Loose prostheses have to be revised using long stemmed implants. The use of additional allo- or autogeneous bone grafting is recommended in the current literature. If the component is loose, revision in periprosthetic fractures after shoulder replacement should be performed according to the functional integrity of the rotator cuff and glenoid bone stock. Reverse shoulder arthroplasty in revision of patient with rotator cuff dysfunction is able to substantially improve shoulder function. However, clinical reports about this injury are rare until today.

a|b
c|d

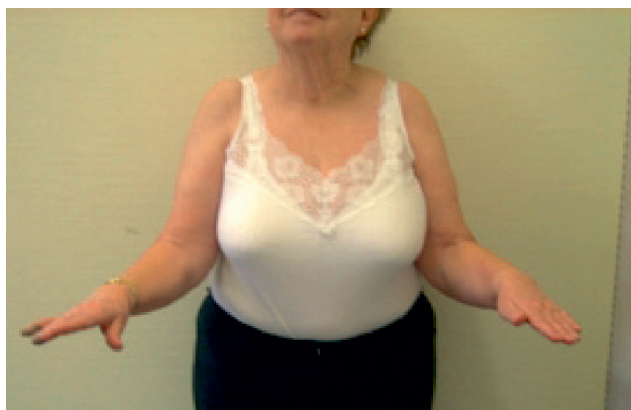


Fig. 22a–d. Clinical result after conservative therapy with almost full range of motion.

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