Reverse Shoulder Arthroplasty: How to Manage Failure

24

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24.1 Introduction

Since its introduction as a treatment for the unreconstructable rotator cuff tear and cuff tear arthropathy in the early 1970s by pioneers like Lipmann Kessel and Ian Bayley [1] in England and Paul Grammont [2] in France, the reverse shoulder arthroplasty (RSA) has become a mainstay of treating these pathologies. With increasing success has followed increasing usage, expansion of indications, and the inevitable increase in complications and revision surgeries [3]. Zumstein et al., in their meta-analysis of current literature, reported an overall complication rate of 20% and that 13% of RSA operations either needed surgical revision of the implants or reoperations [3]. They also concluded that primary RSA was much more successful (fewer complications) than a conversion from an anatomic total shoulder arthroplasty (more complications) by a factor of 1:3.

There appears to be several reasons why the RSA, which represents a true technological breakthrough, has become so popular, which include the changing education of surgeons in training, fee for service revenue models, the "ease" of the surgical technique, and external influences by corporations and the litigation system. Although many of these issues are outside the scope of this chapter, some of these common themes will be mentioned. But, before embarking on a management strategy for a failed operation, it is worth considering whether the failure was due to a surgeon-related technical error, an implant design-related failure, or a general failure related to any arthroplasty. It should however be noted that many of these factors coexist when an operation fails, but it is equally important to identify such components of the failure. Several papers document long lists of causes for the failure of a RSA. However, the vast majority of complications can be grouped into six major categories (Table 24.1) and will be discussed individually.

Table 24.1 Commonest reasons for RSA failure

Instability
Septic complications
Component loosening
Component disassembly
Fractures
General complications

24.2 Instability

The single commonest cause for a revision procedure following a RSA is prosthetic instability (Fig. 24.1). Many causes have been identified as factors and often may coexist. Factors thought to be responsible include loss of articular constraint, previous surgeries, surgical approach, implant

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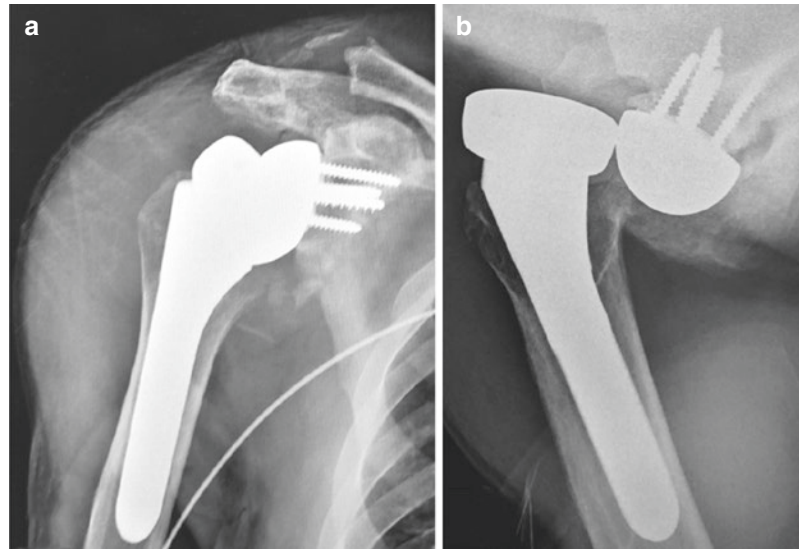

Fig. 24.1 Anteriorly dislocated RSA. (**a**) AP radiograph, (**b**) axillary radiograph

malposition, and causes of altered kinematics. The surgical approach can affect the orientation of component implantation, with a direct superolateral approach, affording a more direct end-on glenoid view. This more direct view may be the reason why this approach has a lesser association with instability (0%) compared to the deltopectoral approach (10%) [4].

Previous surgeries, e.g., failed ORIF/arthroplasty, that are converted to RSA, when compared to a primary RSA, have a three times greater instability rate [4]. These previous surgeries are associated with many important features, notably scar tissues and altered quality of remaining muscle and bone. These altered tissues may well play a significant role in the constraint and behavior of the RSA, thereby influencing instability. Constraint is also affected due to humeral axis shortening, loss of humeral bone stock, distal malposition of the stem, humeral component subsidence or proximally malpositioned (Fig. 24.2), or when the deltoid lever arm is too medialized (due to glenoid bone loss or a smaller glenosphere) [5, 6]. Constraint can also be decreased if the humeral tray is malrotated, which can be readily resolved by component reorientation (Fig. 24.3). Loss of anterior stability can also be the result of subscapularis failure and anterior unipennate deltoid atrophy [6].

When attempting to manage an unstable RSA, understanding the cause of instability is paramount and can broadly be separated into early (<12 weeks) or late (>12 weeks) instability. Moreover, it should be noted that instability is not only a frank dislocation but also when the patient complains of clunking, and apprehension, suggestive of subluxation or maltracking in certain directions.

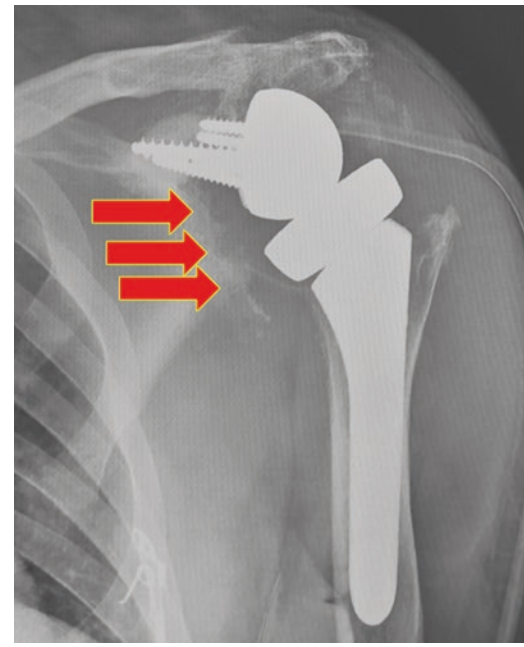

Fig. 24.2 Technical error with a superiorly placed glenosphere leading to notching, and pain, requiring a revision surgery

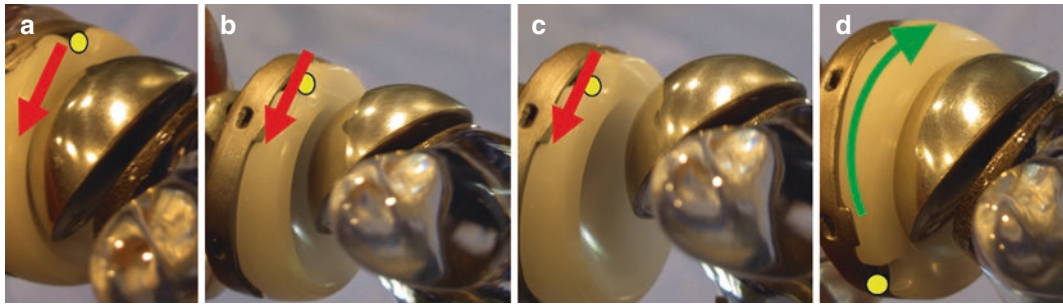

Fig. 24.3 (**a**–**c**) A model demonstration of anterior instability due to component malposition, (**d**) resolved with component reorientation

24.2.1 Management of Early (<12 Week) Instability

An issue with early instability is how aggressive to investigate for bone loss or component malposition. If plain radiographs do not show any obvious deficit, it is reasonable to reduce a dislocated RSA under sedation-anesthesia. A vital part of a reduction procedure is to reduce the joint without excessive force, especially axial twisting, for fear of creating a peri-prosthetic fracture. An equally important and often undermentioned aspect is the subsequent examination under anesthesia (EUA) of the reduced joint to understand the forces and direction required to dislocate/sublux the joint. The findings from the EUA will help to guide the position in which the shoulder needs to be maintained for the next 4–6 weeks, while the soft tissues heal and stabilize the joint. It should be borne in mind that although there may be some real mechanical issues (bone loss or component malpositioning) that could in other circumstance be revised, the majority (59–62%) of cases can stabilize and function well with conservative measures [6, 7].

24.2.2 Management of Late (>12 Week) Instability

If a dislocation occurs after 3 months, or remains unstable with recurrent subluxations, the likelihood of resolving this situation without further surgery is minimal. The two major components to be factored into a subsequent surgical solution are humeral length and/or medialization of the glenosphere. When considering the next step, regardless if the bony anatomy is preserved or not, it is worth acquiring comprehensive imaging studies to assess the position of the greater tuberosity and the total humeral length, as measured by the contralateral limb. These parameters need to be accounted in relation to the deltoid tension.

If the predominant issue is a loss of humeral length, the humeral axis can be lengthened by increasing the polyethylene liner thickness and or using a larger and eccentrically placed glenosphere as inferior as possible, both of which, individually or in combination, may be sufficient to gain stability without the need for humeral component revision. This strategy tends be more useful for less severe humeral bone loss cases.

For cases with greater instability, and significant humeral length deficits, the humeral stem may need to be revised and lengthened, or for massive bone loss cases, a tumor prosthesis and an allograft-prosthetic composite are viable options.

When the issue is determined to be an excessively medialized glenosphere, which presents as continued instability despite correcting humeral length, the strategy has to lateralize the glenosphere. The lateralization allows the deltoid to improve its "wrapping angle," thereby improving stability. Depending on the severity of the case, switching a smaller glenosphere for a larger laterally offset glenosphere may suffice in minor cases, progressing to replacing the proximal humerus bone stock and further lateralizing the glenosphere

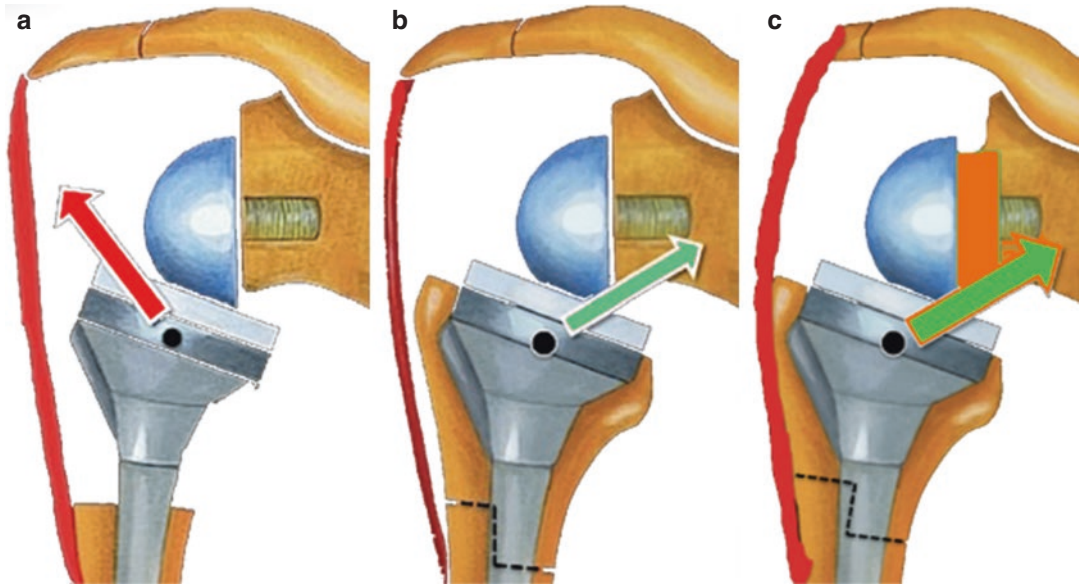

Fig. 24.4 Effect of the deltoid wrapping angle, in relation to the lateralization of the glenosphere and replacing the proximal humeral bone loss (modified from Ref. [10]). (**a**) Deltoid vector directed to cause instability, (**b**) replacement of the proximal humeral bone loss aids to improve the wrapping angle, (**c**) lateralization by using a larger glenosphere and structural bone graft further improves the deltoid wrapping angle and stability

using structural bone graft (Fig. 24.4). Deltoid tension is an important feature of instability, but it is more difficult to correctly gauge when muscle relaxation is used during anesthesia, although muscle relaxation improves surgical exposure. Additionally, the lateralization of the glenosphere allows the deltoid to improve its tension and its coaptation force, thereby aiding stability [8, 9].

Postoperatively, the arm should be maintained in a position of least vulnerability in abduction for a minimum of 4–6 weeks, allowing the deltoid to shrink to its new length.

24.3 Septic Complications

Infection is one of the most devastating causes of RSA failure and is the second commonest reason for revision surgery. Common risk factors for infection include previous surgeries of the shoulder, with the risk increasing with the number of surgeries [6, 11]. Although *Staphylococcus aureus* and *Staphylococcus epidermidis* are common pathogens, propionibacterium acnes has a special predilection for the shoulder as a pathogen [12].

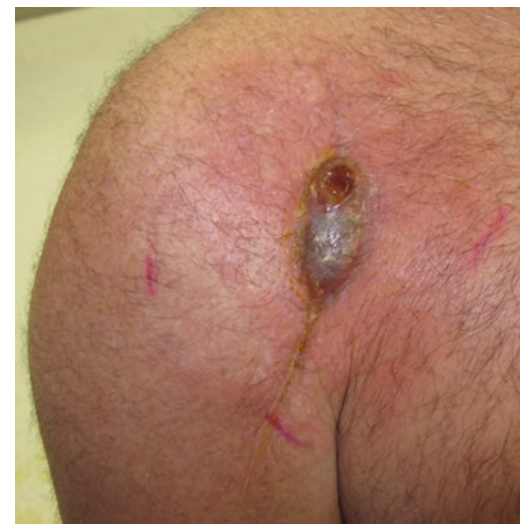

Fig. 24.5 A discharging anterior wound which was treated by a medical team with antibiotics for a month prior to an orthopedic referral. The organism was cultured from a wound swab

Whereas obtaining the diagnosis may be straightforward in some cases (Figs. 24.5 and 24.6), in others a tissue sample is required from the operative intervention. The strategy for managing RSA

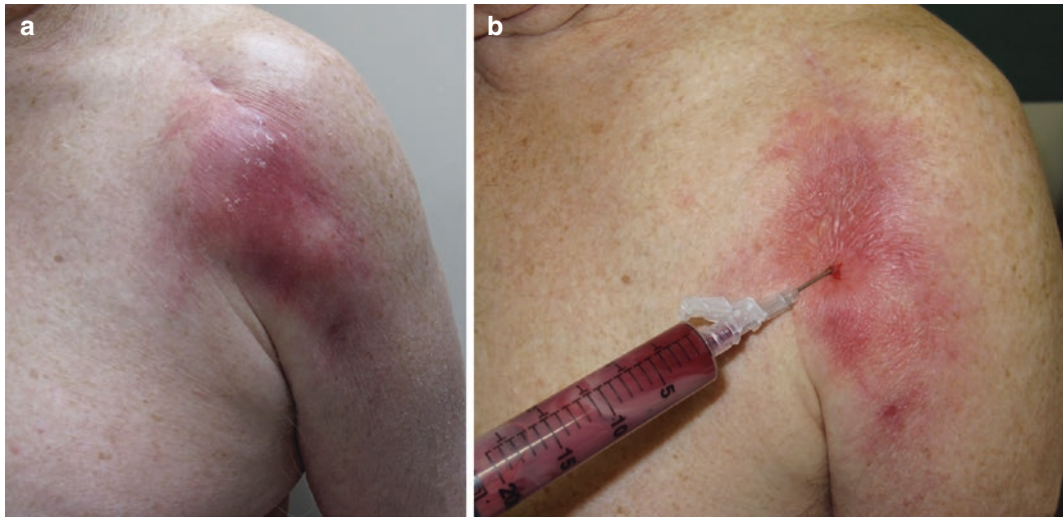

Fig. 24.6 (**a**) Clinical presentation of an infected hematoma after shoulder arthroplasty in a warfarinized patient, (**b**) aspiration and culture revealed *Staphylococcus aureus*, successfully treated with early aggressive wound debridement and antibiotics, without the need for component explantation

infections is based on timing of the infective process, specific pathogen, and the general state of the patient's health and function.

In broad terms, for infections diagnosed and treated within 3 months (acute infections), the overall goal is to preserve the implant (which is well fixed), but to aggressively decrease the infection load. This would entail extensive debridement of soft tissues and exchange of the polyethylene liner and the glenosphere and irrigation of the site (Fig. 24.7). Chronic infections (present for greater than 3 months) in general are not expected to retain the implants and have two widely accepted pathways for treatment. The implant can be removed and the wound derided, thereby resulting in a resection arthroplasty, or the implant can be initially removed, the wound derided and then secondarily re-implanted when the risk of infection is eliminated. The latter option is currently thought to be the gold standard for chronic infections, although a resection arthroplasty is to be considered if that patient is frail and not able to undergo multiple procedures or if the pathogen is resistant. The outcomes of a resection arthroplasty are poor, with a shoulder that is unstable and telescopes with muscle activation [12], but can result in a shoulder that is able to perform basic activities [13]. A third option of a simple surgical debridement and irrigation of the chronic infective site while retaining the implant in situ similar to the management of an acute infection, although not widely recommended, does have proponents [14].

When dealing with a chronic RSA infection, there is some controversy regarding whether the debridement of the infection and reimplantation of the prosthesis should be carried out in a single or multiple, commonly a two-stage, procedures.

While the primary purpose of the intervention is to eradicate infection, an important consideration is the preservation of function. Performing a one-stage procedure results in a better functional outcome, but risks a higher recurrence of infection. A one-stage procedure can be considered in medically compromised patients with a preoperatively known and treatable pathogen, which is often a less common circumstance [12, 15, 16]. However, the two-stage procedure is still considered the gold standard, and this is my recommended approach, while using the normalization of the ESR/CRP/white cell count as adjunctive parameters in deciding that the second stage is definitive. It should be noted that the two-stage procedure has a lesser functional outcome and a higher complication rate, but is more predictable for the eradication of deep infection.

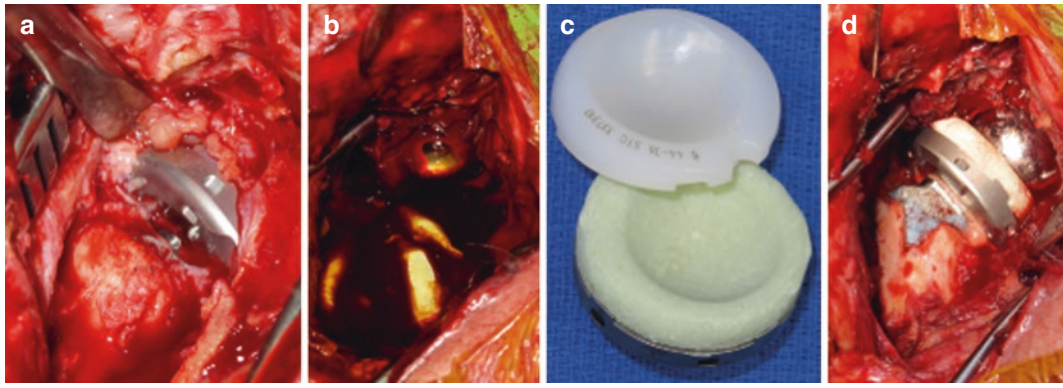

Fig. 24.7 Early infection was identified in a previously infected contralateral shoulder demonstrating a hybrid technique. (**a**) Thorough debridement, (**b**) 10-min agitated Betadine soak with cement rods impregnated with vancomycin and tobramycin, (**c**) the polyethylene is replaced with a custom cement liner impregnated with vancomycin and tobramycin, (**d**) the joint re-articulated with cement spacer

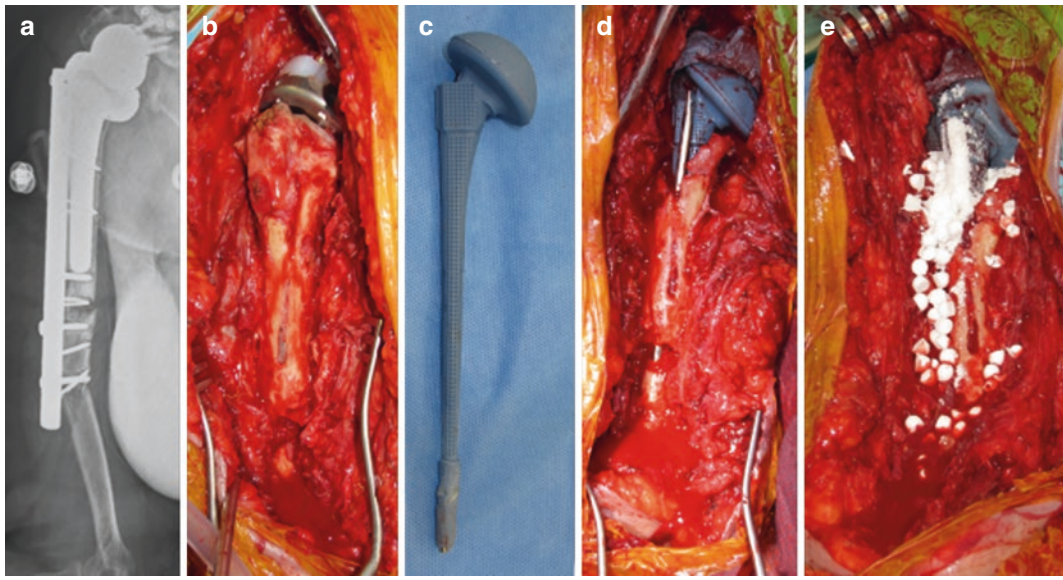

Fig. 24.8 (**a**) Infected peri-prosthetic fracture of a multiply operated RSA, (**b**) cerclage wires removed, cloacae visible, (**c**) a modified vancomycin and tobramycin impregnated ZB Prostalac spacer, (**d**) Prostalac replacement with Steinman pin augmentation for fracture stabilization, (**e**) calcium phosphate beads impregnated with vancomycin placed in surgical site prior to closure

Often, with a commonly used two-stage procedure, when an extensive debridement is undertaken, and the original prosthesis is removed, a cement spacer is employed to maintain the soft tissue space. These spacers are often antibiotic loaded, but the literature does not support their use to improve clinical outcomes, but they appear to improve infection control [17, 18] (Fig. 24.8).

The removal of a well-fixed implant can pose some difficulties but, with the right approach and equipment, tends to be a very achievable challenge. After an extensive wound debridement, and scar release, the joint can be dislocated, and depending on the modularity of the system being revised, modular components can be sequentially removed (e.g., humeral polyethylene tray, followed by the glenosphere). Removing a

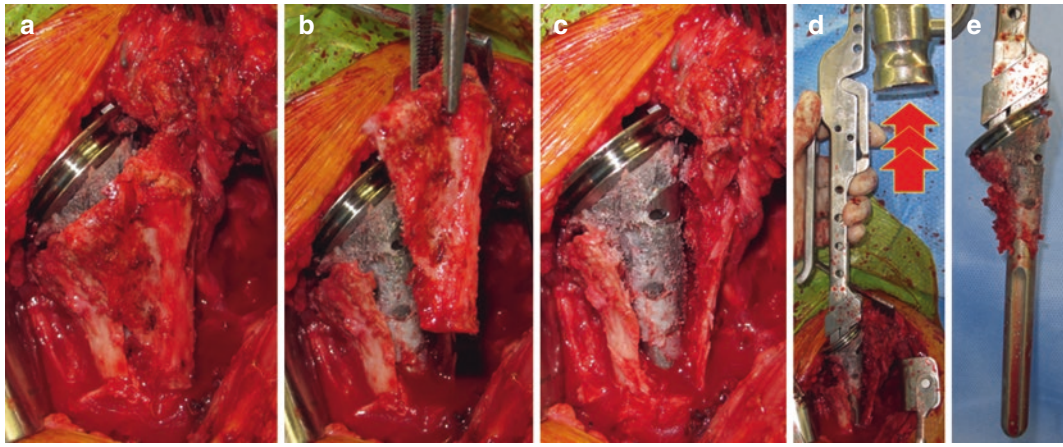

Fig. 24.9 When a stem is well fixed, but needs to be removed during an infected RSA revision, a planned humeral window is useful for assistance with stem extraction, minimizing the risk of iatrogenic fracture. (**a**) A well-fixed humeral stem, (**b**) a planned anterior humeral window is created, (**c**) the humeral window is removed allowing osteotome access to the ingrowth surface of the stem, (**d**) the loosened stem is grasped with a specific handle and a back-slap hammer is used to extract it from the humerus, (**e**) the extracted humeral stem

well-cemented or biologically fixed humeral stem may require flexible osteotomes, ultrasonic cement removal, or a controlled humeral window [19] (Fig. 24.9). A glenosphere baseplate is more problematic since those designs with a significant ingrowth/ongrowth keel/post will potentially cause collateral extraction of glenoid bone stock, and great care should be paid to minimize this bone loss.

24.4 Aseptic Component Loosening

24.4.1 Humeral Component Loosening

Aseptic component loosening is not unique to RSA, and hence is covered elsewhere, where it pertains to the generic loosening and bone loss in relation to shoulder arthroplasty. When the humerus is involved, the same strategies that are employed during a TSA revision are utilized, notably stem and cement extraction (with flexible osteotomes, ultrasonic cement removers, humeral windows), canal preparation, and impaction grafting to augment thinned cortices (Fig. 24.10), allograft/metal plate struts if cortical augmentation is desirable. Finally, long stems are reintroduced to bypass the weakened cortex, or a custom/cortical substitution stem if significant cortical loss exists, and an allograft-prosthetic composite [9] is not suitable.

A reason to reconstruct the proximal bone loss is to improve the coaptation force transmission, by improving the deltoid wrapping angle. A further consideration in the revision case is to augment the power of external rotation, since such cases often, due to the loss of the external rotator musculature, lack the ability to reach the back of their head, etc. Hence, a latissimus dorsi transfer can significantly improve functionality, even in revision cases, but is dependent on proximal bone stock for reattachment [20–22].

24.4.2 Glenoid Component Loosening

An original concern about the longevity of the RSA concept, glenoid component loosening, was because of the expected significant shear stresses predicted at the component-bone interface. Interestingly, glenoid component aseptic loosening has not been as common as feared and can mostly be ascribed to the medialized glenosphere concept championed by Grammont [2]. Although, with more lateralized designs, this

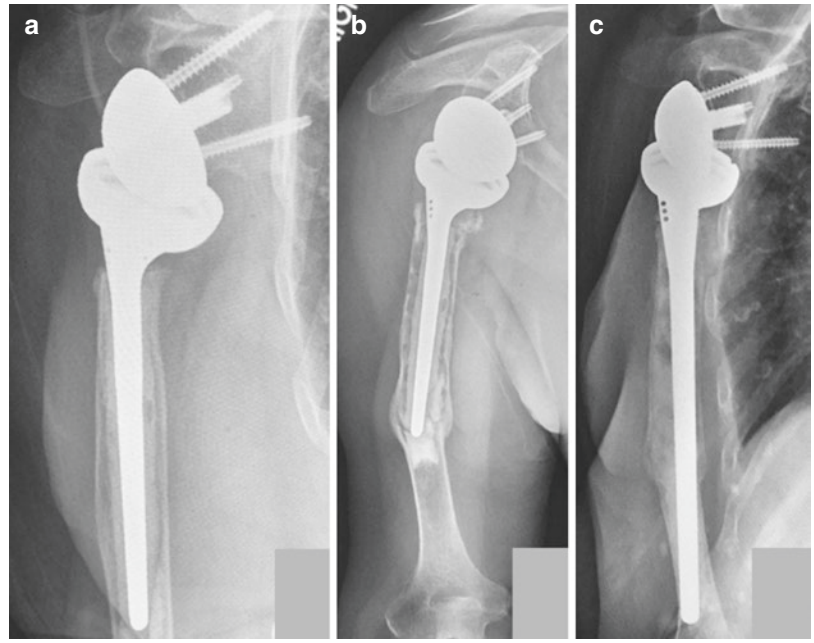

Fig. 24.10 (**a**) A radiographically loose and symptom-free humeral component, presents with acute pain after a fall. (**b**) Peri-prosthetic humeral fracture. The fracture was treated conservatively until union. (**c**) The humeral component was revised with a long stem and a combination of impaction grafting proximally and cementation for early stability distally

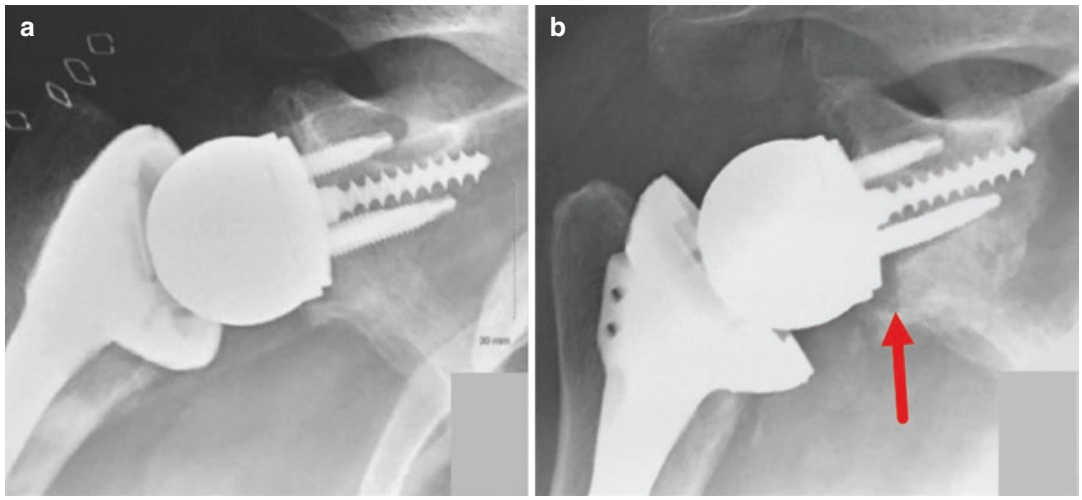

Fig. 24.11 (**a**) Immediate postoperative radiograph of a lateralized RSA. (**b**) early component loosening at 6-week follow-up in a large patient, with a well-placed glenosphere, but a lateralized design

problem can still persist (Fig. 24.11) [23], the majority of aseptic loosening is likely due to technical errors, e.g., superior inclination and placement [24], with trauma as another possibility.

When approaching a loose glenoid component, the first priority is to exclude infection by performing preoperative infection screens and sending intraoperative tissue samples for microscopy. The second most important consideration is the remaining glenoid bone stock after component removal, and hence great care and attention should be paid during this step, in order to minimize unnecessary bone loss. The remaining glenoid bone stock can be categorized as contained or uncontained (partially or complete).

Contained Defects As a general rule, when dealing with bone loss, the best way to reconstitute bone stock is with a structural graft where possible. Small contained defects can adequately be

filled with impacted cancellous bone, with stability achieved by a central screw/peg and peripheral screws that predominantly engage good host bone. For larger contained cavitary defects, a femoral head allograft, cancellous core, is shaped to fit the defect, which achieves some structural stability, and fixed into place with the baseplate central screw/peg and peripheral screws.

Uncontained Defects Whether partially or circumferentially uncontained, structural bone graft with good healing potential is required to reconstruct these glenoids, the optimal graft being a tricortical autologous iliac crest. The defect to be reconstructed can often be predicted from preoperative CT scans. Depending on the surgeon, a decision regarding a custom-made baseplate, incorporating substitution for the defect, versus a biological option, can be made preoperatively. If a biological option is chosen, often in the younger patient, the host fixation bone is used to anchor the baseplate-tricortical graft construct using screws going through the baseplate and the structural graft. The position of the baseplate should be inferior with an inferior inclination.

If the graft fixation is assured and stable, e.g., impaction with a contained defect and good fixation into host bone, without undue force exerted by the humeral component on the glenosphere, upon reduction, then the whole procedure can be completed in a single stage. If fixation into host bone is suboptimal, uncontained defect is being reconstructed, moderate force exerted on the glenoid component by the reduced humeral component, the safer option would a two-stage procedure. The second stage, reimplantation of the humeral component, would be undertaken when there is bony incorporation of the glenoid component and bone stock, e.g., after 3–6 months or after CT evidence.

24.5 Component Dissociation

Although relatively uncommon, the disassembly of an implanted prosthesis dictates a reoperation to reassemble the components. However, the reason for the dissociation has to be understood and rectified (Fig. 24.12). The reason is often multifactorial and can range from surgical technical error (non-congruous placement of glenosphere on baseplate, cross-threading of glenosphere retaining screw, interposed tissue between glenosphere and baseplate or between polyethylene liner and tray or between tray and stem, etc.) [25], implant design, or a traumatic event. When considering the revision option, the cause should be clearly defined, and if purely a traumatic event, ensure correct surgical technique during revision. If technical error is the culprit, the solution is simpler, greater diligence

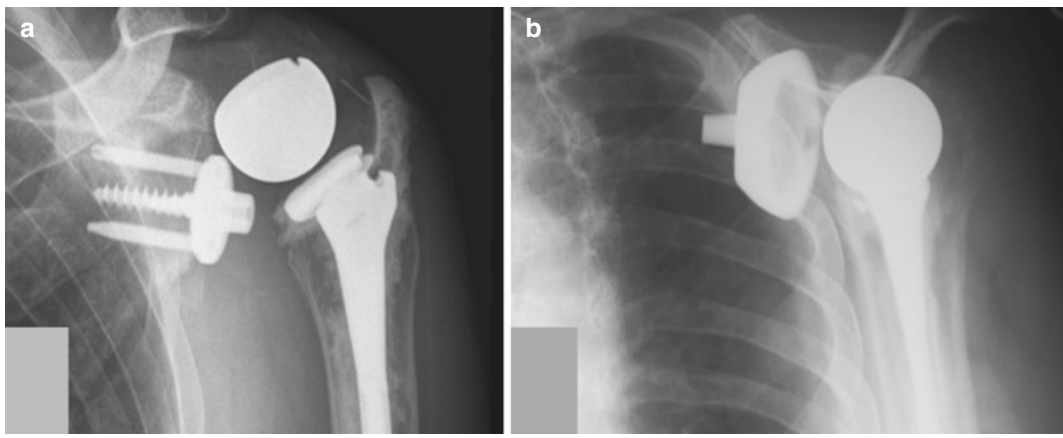

Fig. 24.12 Component failure, (**a**) glenosphere dissociation, (**b**) humeral tray dissociation (with permission from Mark Frankle, MD)

to the procedure. If however the prosthetic design/size allows edge impingement of the components, simply choosing a smaller glenosphere may transfer component impingement to a scapular notching problem. Hence, with larger glenosphere sizes, implicated in glenosphere dissociation [26], we recommend downsizing the glenosphere diameter and performing a controlled notchplasty.

24.6 Acromial Fracture

Acromial fractures are a recognized complication after RSA, generally thought to be a fatigue fracture mechanism, and can occur at any stage in the postoperative course. Risk factors include previous acromioplasty, osteoporosis [27], excessive deltoid tensioning, and direct trauma. The clinical outcomes are adversely affected by some acromial fractures, but not all. The literature is non-conclusive regarding the management, and although conservatively managed acromial fractures result in diminished outcomes, they are improved compared to the post-injury state [28]. Fracture fixation, although an option, should be weighed against the ability to predictably gain a stable fixation. However, displaced scapular spine fractures benefit from ORIF, while anterior acromial avulsions may consistently be treated with nonoperative management [29]. It should be noted that operatively treated acromial base fractures are unpredictable with respect to the final outcome and not significantly different to nonoperatively treated cases [30].

24.7 Scapular Notching

Scapular notching is a unique problem of RSA and occurs with medial and posteromedial contact between the prosthetic humeral component rim and bony scapular neck. While symptomatic, with a presentation of pain, and radiographically visible, the clinical significance of notching has been poorly understood. More recently there has been an association between scapular notching and poorer clinical outcomes [31]. Avoidance of this issue is based on a combination of prosthetic design (more lateralized glenosphere) [32] and an inferior baseplate placement [33]. However, there is no consensus regarding the management for a patient who presents with notching, with or without pain. On two (personal experience) occasions with the presentation of a well-fixed but painful scapular notching, a surgical notchplasty was performed, after optimization of the modular components (Figs. 24.13 and 24.14). When the notching is severe, not only is the polyethylene liner damaged by the contact, it generates polyethylene wear debris and possibly even metallosis with contact with the inferior glenosphere screws and/or metal rim of the humeral component. At a revision surgery, the metallosis debris is seen as a blackened synovitis which should be derided.

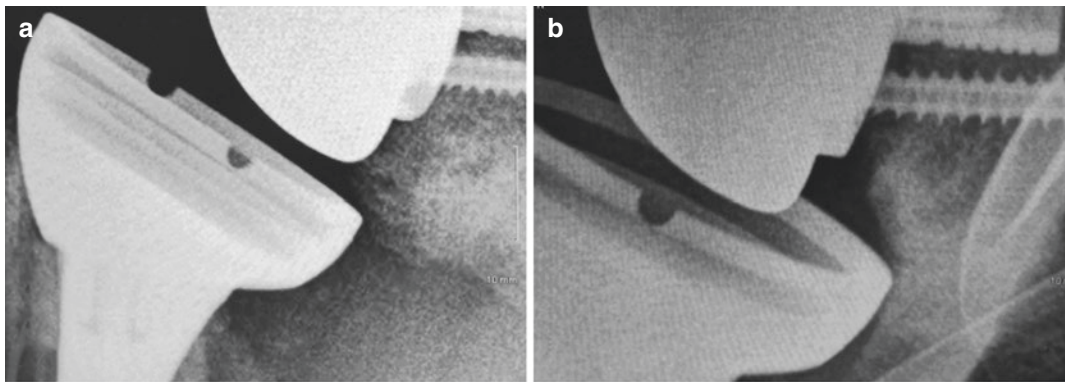

Fig. 24.13 (**a**) Medialized RSA without inferiorization to the margin of the glenoid. (**b**) After 3 years, the patient returned with painful scapular notching and grinding

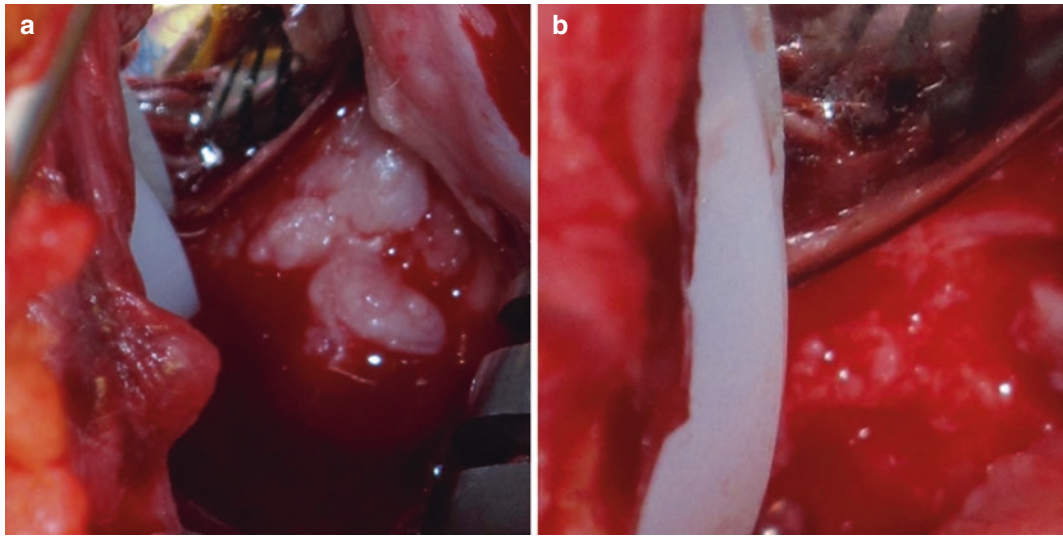

Fig. 24.14 (**a**) Painful inferior scapular notching. (**b**) Surgical "notchplasty" of inferior scapular bone. The extent of notchplasty was gauged by lack of humerus-scapular neck contact with maximal intraoperative adduction and internal-external rotation

Conclusion

Always think of infection when assessing a failed RSA, loose component(s), and performing a revision surgery, and act by obtaining preoperative infection indices (for absolute and tracking purposes).

Recommendation Always send intraoperative tissue samples from the soft tissues and from within bony cavities for microscopy, culture, and sensitivities.

Assess bone stock with respect to the pathological process and the surgical process of revision. Whereas the pathological process can diminish bones stock due to septic or aseptic loosening, the surgical process may, by necessity, further diminish the bone stock, thereby complicating the revision surgery. For example, when revising a glenoid component with and in growth trabecular metal post, an over-coring drill helps to remove ingrowth component, at the expense of added glenoid bone stock.

Recommendation Respect and preserve bone stock, especially the glenoid, and consider using a glenoid component that does not have a sizable ingrowth glenoid post.

Since the deltoid is the main motor driver for the reverse construct arthroplasty, all efforts during surgical exposure and subsequent tensioning of the implant should focus on minimizing trauma to this muscle. This includes avoiding deltoid-splitting approaches and overtensioning to construct.

Recommendation Regardless of the previous approaches utilized in a failed case, approach the revision scenario with a deltopectoral approach, and take extra care to gain stability without overstuffing the joint.

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