Elbow Fusion for The Unstable Elbow

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Background

Elbow fusion is an operation that is, for the most part, limited to young active individuals that really have no other reconstructive options for the elbow. The patients' have either sustained severe trauma to the elbow or they have failed multiple previous surgical interventions to the elbow, which has resulted in severe bone loss and instability of the elbow. These individuals are not typically good candidates for total elbow arthroplasty. Limitations after total elbow arthroplasty include a five-pound lifetime lifting restriction and the younger patient can have a difficult time abiding by these rules often resulting in multiple revision surgeries. A resection arthroplasty is not always a great functional solution as well since it often leaves the elbow very unstable and the patients describe difficulty with positioning the hand in space and using the arm with any type of resistance. The advantage of an elbow fusion is that it provides permanent stability to the elbow, which better positions the hand in space for functional resistance but it comes with a great cost in that the patient no longer has full capability of the elbow. The decision to fuse the elbow in a more flexed or extended position is made jointly by the surgeon and the patient, but obviously will compromise activity in one of the planes of functional activity depending on the position chosen.

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Evaluation

The key to evaluation for these patients is to be certain that the patient has realistic expectations and that they are properly educated about what it means to have a fused elbow. You must also understand their motivation for an elbow fusion and what they are expecting to achieve. This procedure has a drastic end result from a functional standpoint but it also has great advantage. They will stop the endless surgical interventions and have the potential to obtain good pain control and stability of the elbow but it comes at the cost of losing some elbow function and the ability to do selected activities. You must look at the entire patient; look at their hand dominance, job requirements, and their hobbies and understand why they would not be a candidate for a total elbow arthroplasty or a resection arthroplasty or other reconstructive options. Often times these patients have had multiple previous surgical interventions and therefore it is important to obtain all previous operative notes, clinic notes, laboratory studies, EMG studies, or advanced imaging such as MRIs or CT scans. You also need to have a good understanding of the associated comorbidities

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that will weigh in on your decision to fuse and their risk for surgery.

On physical examination you want to be sure that there is no ongoing concern for infection since this will compromise your ability to achieve union. You want to assess the soft tissue and bone quality. Many times these patients have had multiple procedures and so you want to be sure that you will have enough soft tissue coverage to allow for healing. The bone can be shortened in order to facilitate soft tissue coverage. If the patient has had a previous soft tissue procedures such as a free flap, then you will want to consult with your plastic surgery colleagues to be sure you are clear on the development of the soft tissue planes for the procedure and in most cases it would be wise to have them involved at the time of the surgical procedure. Bone loss is very common and you will need to determine the viability of the bone and the ability to approximate the bone to allow for solid healing. If you have removed previous hardware, then the fusion plate should extend two cortical widths past the last screw hole to prevent later fracture. Neurovascular status should be assessed. The hand should ideally be functional; however, an argument can be made that even just having a stable forearm and nonfunctional hand to act as an opposing pain free limb can also increase overall function. In these situations it can be helpful to discuss prosthetic options with a physical medicine and rehabilitation specialist who can advise the patients' on the risks and benefits of amputation and potential for future prosthetic options.

Treatment Algorithm

Nonoperative Strategy/Therapy Protocols

Usually patients have attempted to wear removable orthoses to help provide some external stability to the elbow but unfortunately these are not really well tolerated. They tend to create pressure sores around the elbow and can be bulky and uncomfortable. Resection arthroplasty does not relieve pain entirely and patients describe achiness or even more severe pain because of the lack of ligamentous and bony support. The resection arthroplasty can be very dysfunctional as it does not allow them to work with their arm over their head due to triceps insufficiency and it does not provide stability to allow for activity against resistance. Younger patients find it difficult to function with a resection whereas older individuals who are more sedentary may have an easier time coping.

When deciding to electively fuse an elbow, it is critical to allow the patient to experience in real time what it would be like to live with a permanently stiff elbow. Some authors talk about using an orthosis; however, this can still be misleading to a patient if they, even occasionally, remove the splint to perform an activity. Preferably, the patient should be rigidly casted for 1 week ideally. If they are casted in a rigid position, then this will truly give them the sense of what it would be like to live with their elbow permanently fused and what it would be like to perform activities of daily living with no "opt out." This can be very helpful for the patient to decide if this is a feasible option for them and to decide on the actual position. The optimal fusion position has been discussed before in previous articles [1–4]. With the original description of elbow fusion, patients were typically fused at 90° [5]. It has been concluded that there is no single optimal elbow fusion position to cover all activities of daily living [1, 4]. O'Neill et al. found that 90° allowed most individuals to take care of personal hygiene needs and that a 70° angle made reaching for objects easier [1]. Tang et al. reported functional activity scores for healthy individuals who were locked in elbow braces at increments of 20° [2]. They reported that functional scores for personal hygiene and activities of daily living were more optimal at 110° compared to 90°; however, they agreed that their functional tasks measured had a bias towards activities that require more elbow flexion. Groot et al. concluded that the optimal elbow arthrodesis position should bias toward either the flexion domain or the extension domain depending on the patient's preference [3]. The patient should try different fusion angle options to see what works best for them. With the rise of technology and computer use, often times an elbow fused around 70° is optimal and it tends to be less obvious clinically when the patient is ambulating since their arm can still rest down by their side whereas with a fusion at 90° it is more obvious that the elbow is contracted.

Surgical Management/Technique/ Surgical Pearls

It is important to plan preoperatively for these cases to firstly decide on the optimal fusion angle, which is individual to the patient, and also to plan the actual fusion technique. The author has had success using a large 4.5 LCD plate, which is pre-bent to the optimal angle of fusion position determined preoperatively by the patient. The plate is given to one of our machinists who pre-bend the plate in a controlled fashion to the specified angle; this can also be done in the operating room but the 4.5 plate is a very stout plate and can be difficult to bend with the intraoperative plate bender. Depending on the bony deformity, it is best to think how the bones will align with one another with the most surface area for healing, i.e., a chevron, oblique, or a step cut for example.

Surgical Technique

The patient is in a supine position. The author prefers this position as it allows one to visualize the elbow in a normal anatomic position. An argument could be made to place the patient in a lateral position, which would allow easier access for application of the plate. A midline posterior incision is preferable provided that there are no special soft tissue considerations. Thick fasciocutaneous flaps are elevated medially and laterally. The ulnar nerve is formally transposed or decompressed in situ. The author prefers formal subcutaneous transposition. The triceps is mobilized using a splitting approach. The radial nerve is identified and protected proximally between the long and lateral heads of the triceps muscle. The split is carried through deeper medial head of the triceps through its midline being careful to protect the ulnar nerve medially and then carried down to the joint and down to the crest of the ulna. The bones ends are cut to expose bleeding bone to maximize surface are for healing and the intramedullary canals are cleared of any debris or sclerotic bone to maximize healing potential. The plate can be used as a template to help shape the cut of the two bone ends. Once the bones have been shaped to optimize contact at the correct angle, a large interfragmentary compression screw is used perpendicular to the cut angle to allow compression at the fusion site. Large fragment clamps can also be placed perpendicular to the cut surface to compress the site before the screw is tightened. The 4.5 plate is then placed along the posterior cortex of the humerus and the ulna to complete the fusion with eight cortices above and below the fusion site. The area is then packed with autogenous bone graft. The bone graft is classically harvested from the iliac crest but the author has also harvested from the ipsilateral proximal tibia. The triceps split and the soft tissues across the olecranon crest are then closed over the plate to optimize blood supply to the area. The subcutaneous tissue and skin are closed in standard fashion. The patient is provided with a simple sling but is not allowed any weight bearing or resisted activity until there is bony fusion. At 4–6 months post op the patient undergoes a CT scan looking for evidence of bony bridging across the fusion site based on evidence of more solid healing on the plain film images. Once bony healing across the osteotomy site is confirmed, the patient can start a gentle strengthening program. The patient is instructed to maintain full shoulder wrist and hand range of motion.

Published Outcomes/Complications

The outcome literature for elbow arthrodesis is limited to small series and case reports [6–16]. The first reported cases were in 1926 where they describe an elbow arthrodesis in a 28-year-old female who has developed tuberculosis of the elbow and after subsequent irrigation and debridement procedures developed a dysfunctional flail elbow. The patient improved their function after an elbow fusion. The second case reported in this paper was for a 17-year-old male who had a flail elbow due to poliomyelitis [5]. In 1967, Koch et al. reported on 17 cases of elbow arthrodesis performed at the Mayo Clinic [17]. They attempted various techniques and reported successful fusion in 8 out of 17 cases. They reported that the most successful technique utilized tibial graft in the humeral canal with additional autogenous bone and temporary fixation with a Steinmann pin that was later removed. McAuliffe et al. in 1992 reviewed retrospectively 15 patients who had an elbow arthrodesis utilizing an AO compression plate technique [18]. Arthrodesis was successful in 14 out of 15 patients. They described eight patients having exposed plates due to severe soft tissue loss. These plates were later removed after healing and then allowed for soft tissue closure. The authors reported two forearm fractures that were thought to be related to ghost screw holes below the fusion plate and they recommended extending the fusion plate beyond previous screw fixation. Koller et al. in 2008 reported outcomes for 14 patients; 11 patients had a compression plate technique and the remaining three had an external fixation technique [19]. Successful union was reported in 11/14 patients. Complication rate was 43 % (6/14) resulting in revision surgery for skin breakdown, deep infection, implant failure, and delayed union. Sala et al. report an Ilizarov technique for elbow fusion in four patients with success of fusion in 3/4 patients [20].

Cases

Case #1: Severe Trauma

This is a 32-year-old male who was involved in a motor vehicle collision and he has sustained severe trauma to his elbow with a near amputation. He had significant loss of bone and also soft tissue loss requiring soft tissue reconstruction by the plastic surgery service. The patient had also lacerated his radial nerve and required tendon transfers later in his recovery for loss of function. He elected to undergo an elbow fusion since he was a manual laborer and would not be able to function with a five-pound lifetime lifting restriction that would be required for an elbow replacement. He presented, at the time of the trauma, with deficient distal humeral and proximal ulnar bone. The bone was lost at the scene of the initial accident (Fig. 17.1). He was initially placed in an

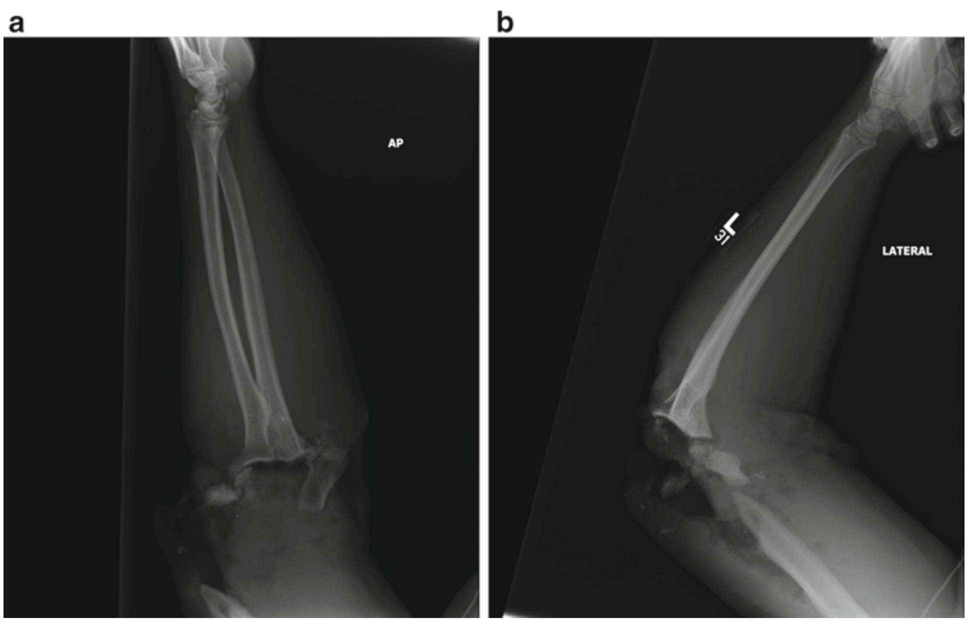

Fig. 17.1 AP (**a**) and lateral (**b**) image showing severe acute loss of distal humeral and proximal ulnar bone

external fixator and antibiotic beads were placed for infection prevention (Fig. 17.2). After multiple washout procedures he was ready for his bony reconstruction. His bones approximated best with an oblique cut of the distal humerus to match the deficient proximal ulna. The area was compressed with a large interfragment screw and then further stabilized posteriorly with a large 4.5 plate (Fig. 17.3). The patient felt that a fusion closer to 90° would be better for him since he was a laborer and needed to carry heavy objects. CT scan at 4 months shows bony union of the fusion site (Fig. 17.4). He continues to function in a manual labor occupation.

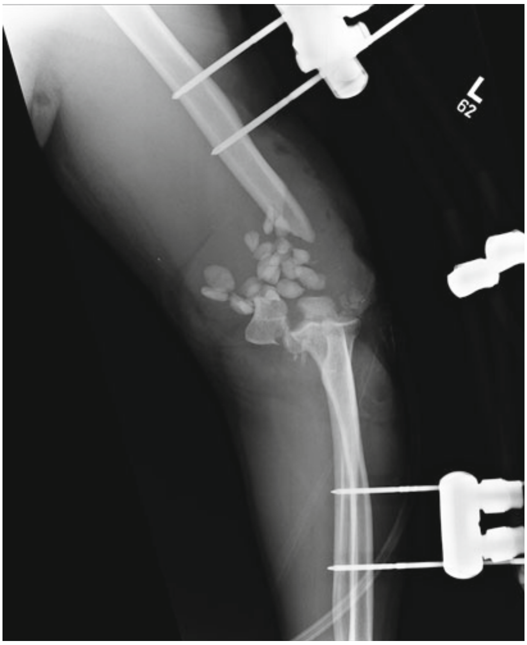

Fig. 17.2 AP image showing external fixation and antibiotic beads

Case #2: Chronic Elbow Pain

This patient, at the age of 23, was diagnosed with a giant cell tumor of the distal humerus and underwent a total elbow arthroplasty with a tumor prosthesis and allograft reconstruction. Unfortunately, she then required multiple total elbow revision procedures and then developed an infected total elbow replacement and presented at the age of 38 years with a long stem total elbow replacement, that was infected with cement extending to the humeral head, and severe humeral bone loss (Fig. 17.5). She then underwent an explanation of the implant with removal of all infected cement and placement of antibiotic spacers (Fig. 17.6). She had the usual IV antibiotic treatment and was cleared of her infection but could not live with pain and instability created by the resection. After a series of cast treatments she decided that she was more functional with her elbow in a more extended position, likely

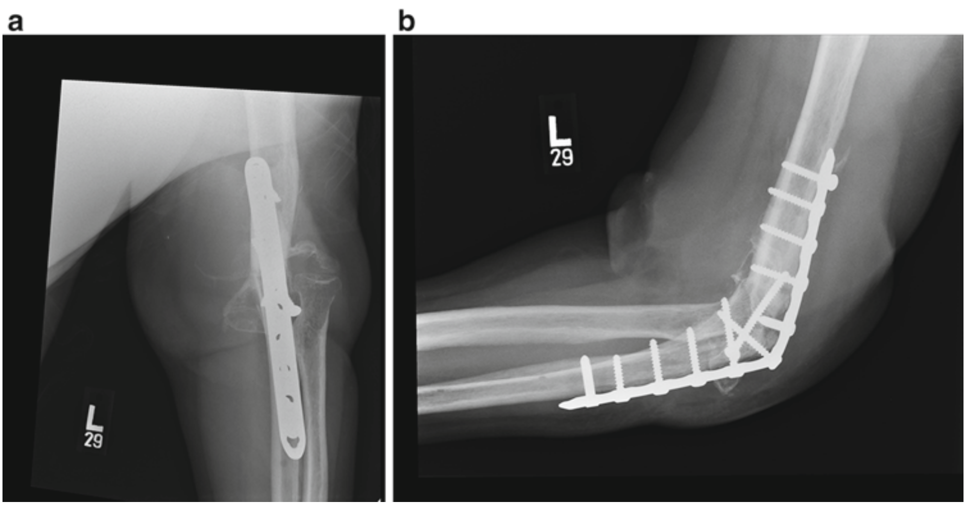

Fig. 17.3 AP (**a**) and lateral (**b**) plain image of healed elbow fusion

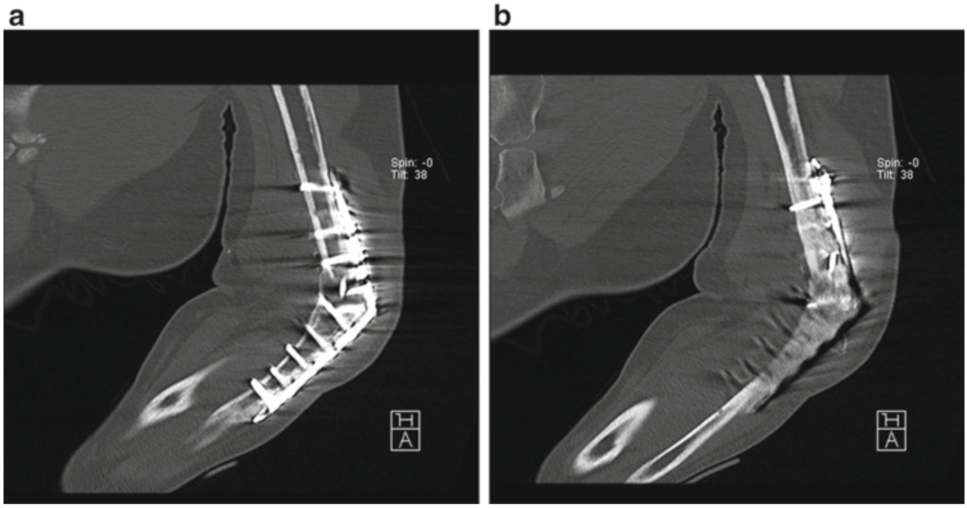

Fig. 17.4 Two representative lateral CT scan images (**a**, **b**) showing healed fusion

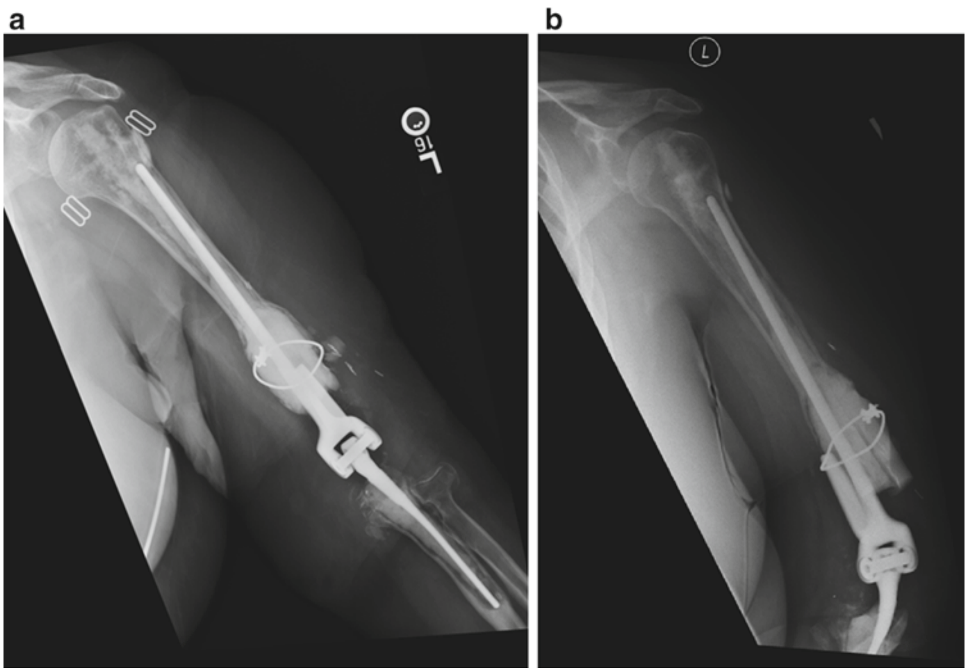

Fig. 17.5 Presentation plain film images (**a**, **b**) showing long stem cement total elbow arthroplasty

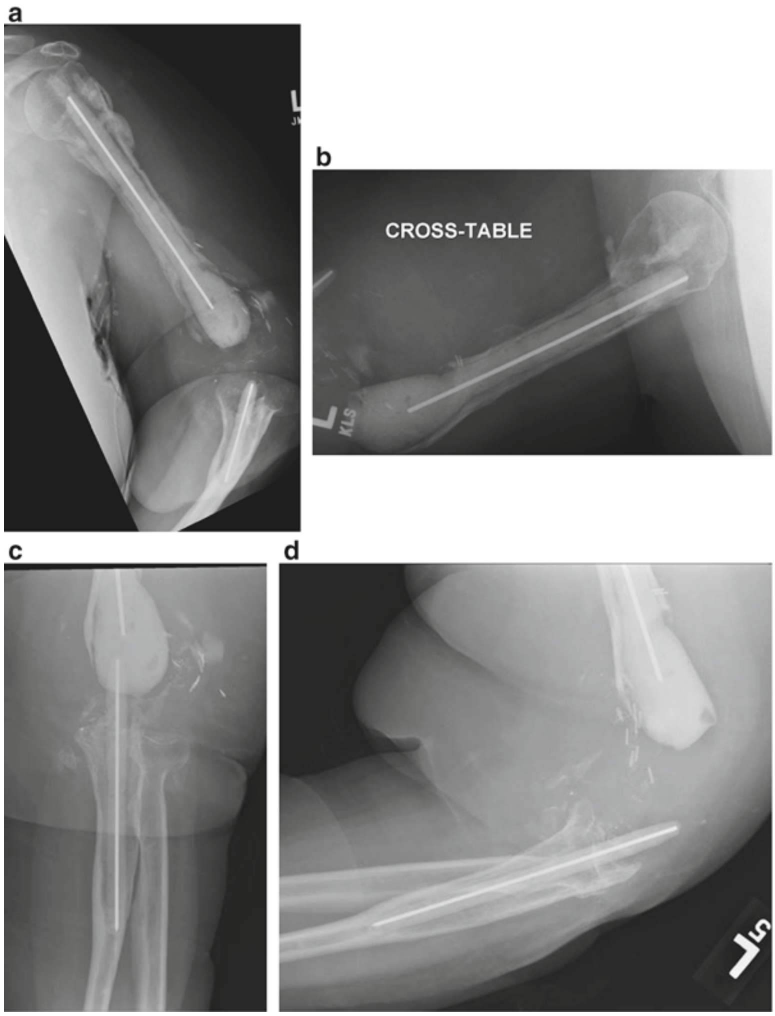

Fig. 17.6 Plain film images (**a**–**d**) showing resection of total elbow arthroplasty and antibiotic spacers

due to the fact that she had severe shortening of her humerus. At age 40 she underwent a fusion of the elbow at 40° (Fig. 17.7). An oblique cut of the bone allowed for an appropriate fusion surface that was initially compressed with a large inter-fragment screw (Fig. 17.8). You will note that the antibiotic cement spacer for the humerus was kept in situ thinking that it was providing support to the bone since it was already osteopenic. Her pain control improved and her ability to touch her head with good control and use her arm overhead improved due to the stability of the elbow.

Conclusions

In conclusion, an elbow fusion is a reasonable consideration in the young patient when all other reconstructive options for a severely damaged elbow have failed. It has the advantages of providing stability to the elbow and improving pain; however, it comes at a considerable loss of selected function of the extremity depending on the angle of fusion. The patients must be carefully chosen and must also be fully informed

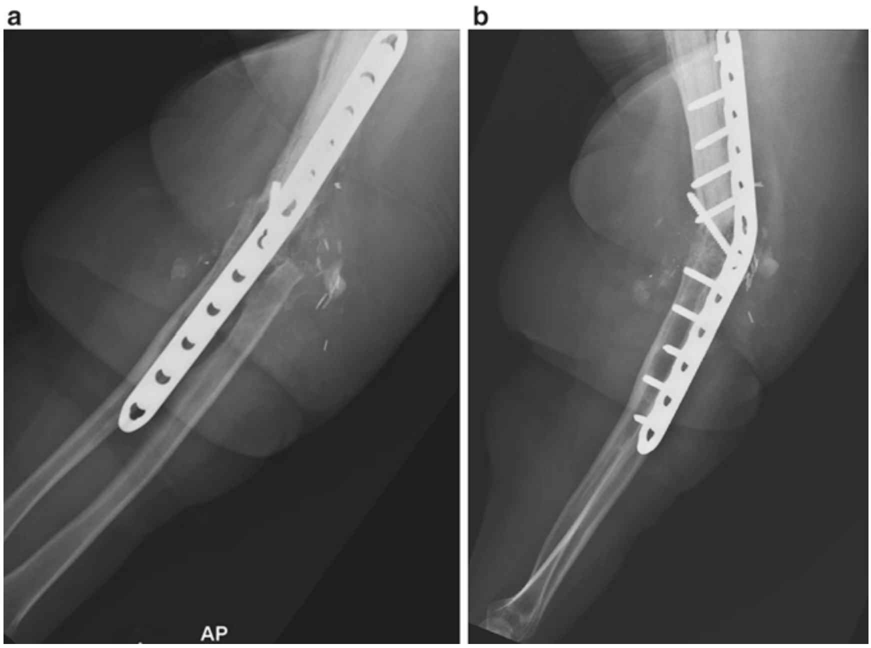

Fig. 17.7 AP (**a**) and lateral (**b**) showing healed fusion of elbow joint

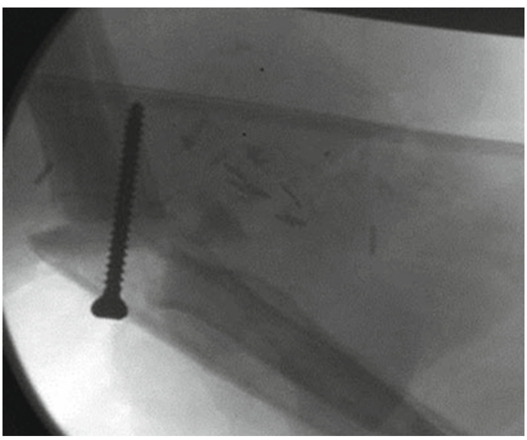

Fig. 17.8 Intraoperative image showing interfragment screw placement across fusion site to allow for compression

about the potential risks and benefits of this procedure. Preoperative planning with the use of casting to determine optimal fusion angle can be very helpful for elective cases. Stable plate fixation with compression at the fusion site is the authors' preferred surgical technique.

References

1. O'Neill OR, Morrey BF, Tanaka S, An KN. Compensatory motion in the upper extremity after elbow arthrodesis. Clin Orthop Relat Res. 1992;(281):89–96.
2. Tang C, Roidis N, Itamura J, Vaishnau S, Shean C, Stevanovic M. The effect of simulated elbow arthrodesis on the ability to perform activities of daily living. J Hand Surg Am. 2001;26(6):1146–50.
3. de Groot JH, Angulo SM, Meskers CG, van der Heijden-Maessen HC, Arendzen JH. Reduced elbow mobility affects the flexion or extension domain in activities of daily living. Clin Biomech. 2011;26(7):713–7.
4. Nagy 3rd SM, Szabo RM, Sharkey NA. Unilateral elbow arthrodesis: the preferred position. J South Orthop Assoc. 1999;8(2):80–5.
5. Ashhurst AP. Arthrodesis of the elbow. Ann Surg. 1926;83(1):104–10.
6. Kovack TJ, Jacob PB, Mighell MA. Elbow arthrodesis: a novel technique and review of the literature. Orthopedics. 2014;37(5):313–9.
7. Lerner A, Stein H, Calif E. Unilateral hinged external fixation frame for elbow compression arthrodesis: the stepwise attainment of a stable 90-degree flexion position: a case report. J Orthop Trauma. 2005;19(1):52–5.

8. Orozco R, Giros J, Sales JM, Videla M. A new technique of elbow arthrodesis. A case report. Int Orthop. 1996;20(2):92–9.
9. Otto RJ, Mulieri PJ, Cottrell BJ, Mighell MA. Arthrodesis for failed total elbow arthroplasty with deep infection. J Shoulder Elbow Surg. 2014;23(3):302–7.
10. Staples OS. Arthrodesis of the elbow joint. J Bone Joint Surg Am. 1952;34-A(1):207–10.
11. Gellman M. Arthrodesis of the elbow a preliminary report of a new operation. J Bone Joint Surg Am. 1947;29(4):850–2.
12. Rashkoff E, Burkhalter WE. Arthrodesis of the salvage elbow. Orthopedics. 1986;9(5):733–8.
13. Bilic R, Kolundzic R, Bicanic G, Korzinek K. Elbow arthrodesis after war injuries. Mil Med. 2005; 170(2):164–6.
14. Ozer K, Toker S, Morgan S. The use of a combined rib-latissimus dorsi flap for elbow arthrodesis and soft-tissue coverage. J Shoulder Elbow Surg. 2011; 20(1):e9–13.
15. Vaishya R, Singh AP, Singh AP. Arthrodesis in a neuropathic elbow after posttubercular spine syrinx. J Shoulder Elbow Surg. 2009;18(4):e13–6.
16. Song DJ, Wohlrab KP, Ingari JV. Anterior ulnohumeral compression plate arthrodesis for revision complex elbow injury: a case report. J Hand Surg Am. 2007;32(10):1583–6.
17. Koch M, Lipscomb PR. Arthrodesis of the elbow. Clin Orthop Relat Res. 1967;50:151–7.
18. McAuliffe JA, Burkhalter WE, Ouellette EA, Carneiro RS. Compression plate arthrodesis of the elbow. J Bone Joint Surg Br. 1992;74(2):300–4.
19. Koller H, Kolb K, Assuncao A, Kolb W, Holz U. The fate of elbow arthrodesis: indications, techniques, and outcome in fourteen patients. J Shoulder Elbow Surg. 2008;17(2):293–306.
20. Sala F, Catagni M, Pili D, Capitani P. Elbow arthrodesis for post-traumatic sequelae: surgical tactics using the Ilizarov frame. J Shoulder Elbow Surg. 2015; 24(11):1757–63.