## 2.3 Articular fractures: principles

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2.3 Articular fractures: principles

1 Anatomy and basic principles

Diarthrodial joints provide a smooth, stable articulation between the bones of the appendicular skeleton so that they may take on special tasks. Joints vary widely in their structure, but share common features essential to their function. A synovial joint consists of two end segments of bone bound together by a fibrous capsule. In certain areas, this capsule has specialized into discrete ligaments. The articulating end segment of bone is covered with resilient, elastic, and avascular hyaline cartilage, which helps to distribute force to the underlying subchondral bone [1]. While the articulating surface of each bone is smooth, opposing joint surfaces may have variable areas of contact between them at different positions of joint motion. Joint stability relies on passive stabilizers, namely bone and joint morphology, and the surrounding ligaments. Active stabilization is provided by the muscles that cross the joint. The capsule is lined with a membrane that produces a dialysate of blood: the synovial fluid, rich in hyaluronic acid, which provides lubrication and nutrition for the articular cartilage surfaces. Maintenance of a healthy articular segment is dependent on joint motion and repetitive loading. Disruption of any component of the joint can result in altered joint function because of the pathological processes of arthrosis or osteoarthrosis. For example, displaced intraarticular fractures are associated with gaps or steps at the joint surface, along with possible dissociation or malalignment of part or the entire articular segment from the meta-/diaphyseal supporting skeleton. This alteration in joint morphology can immediately affect stability, cause pain, and disrupt effective motion of the joint and the joint mechanics. The inflammatory response associated with such an injury can lead to extensive fibrosis within an injured joint. This response can be exacerbated by inappropriate immobilization or surgical procedures. For these reasons, closed reduction and external immobilization were commonly unsuccessful in the early treatment of displaced intraarticular fractures. The early result following fracture consolidation was commonly a bone deformity with associated stiffness, pain, and functional disability. Overall motion was later improved using traction and joint mobilization, but instability and incongruity of the joint persisted.

To avoid the complications of closed treatment, Charnley [2] proposed that perfect anatomical restoration and freedom of joint movement could only be obtained by simultaneous open reduction and internal fixation.

However, the early implants were unable to achieve sufficient stability to allow immediate motion and prevent displacement. Therefore, patients received the worst possible combination of treatments: there were the risks of open reduction on the one hand and the complications of long-term external immobilization on the other. With the advent of antibiotics, improved soft-tissue handling, new implant designs, and a better understanding of the injuries by surgeons experienced in fracture care, open reduction and internal fixation of intraarticular fractures became safer and more widely accepted. The initial results, following the AO principles of operative fracture treatment, confirmed that absolute stable internal fixation and early joint motion improved x-ray and clinical results [3].

Based upon experimental and clinical studies, the current philosophy of operative treatment of these injuries has been
developed. Schatzker, in 1987, outlined these principles as follows:

- Plaster cast immobilization of intraarticular fractures results in joint stiffness.
- Plaster cast immobilization of intraarticular fractures combined with open reduction and internal fixation results in much greater stiffness.
- Depressed articular fragments are impacted and will not be reduced by closed manipulation and traction.
- Major articular depressions do not fill with fibrocartilage; instability, which results from their displacement, is permanent.
- Anatomical reduction and stable fixation of articular fragments is necessary to restore joint congruity.
- Metaphyseal defects beneath reduced articular segments must be filled with structural bone graft or substitute to prevent articular fragment redisplacement.
- Metaphyseal and diaphyseal displacement must be reduced to obtain proper limb alignment and prevent joint overload.
- Immediate motion is necessary to prevent joint stiffness and to ensure articular healing and recovery. This requires stable internal fixation.

2 Mechanism of injury

There are two common mechanisms of injury for articular fractures:

1. **The indirect application of force**, producing a bending moment through the joint, which drives a part of the joint into its opposing articular surface. This is the most common. Usually the ligaments are strong enough to initially resist this eccentric load, converting the bending moment to direct axial overload, fracturing the joint surface. Typically, this results in a partial articular fracture ([Fig 2.3-1a](#)).

2. **The direct application of force**, either directly to the meta-/diaphyseal component of the joint, or through axial transmission of force from one end segment of bone to the opposing articular surface ([Fig 2.3-1b](#)). This direct crushing or axial application of force causes an explosion of the bone and a dissipation of force into the soft tissues. Complete multifragmentary articular fractures, with associated severe soft-tissue injuries, are the result ([Fig 2.3-2](#)). The bone quality, the position of the limb, and the exact vector of the force will determine the fracture pattern.
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Fig 2.3-1a–b There are two mechanisms that commonly cause an articular fracture.

a An eccentric load or indirect force, which causes excess pronation or supination, varus or valgus movement to any joint. Loading one side of the joint usually produces a split or shearing fracture, while a pull on the ligamentous insertions on the opposite side results in an avulsion fracture or torn ligament.

b The other mechanism is an axial loading force, which allows one component to act as a hammer on the other, producing an impaction of the articular surface or, if more severe, an impaction with fracture fragmentation of the metaphysis or even diaphysis.

Fig 2.3-2a–c Direct force transmission (fall from a height) results in severe fracture impaction/dislocation (a–b) and associated soft-tissue injury (c).
2 Decision making and planning

3 Evaluation of the patient and the injury

Because the etiology of many of these injuries is a high-energy mechanism, it is important to evaluate the patient fully for associated musculoskeletal and nonorthopedic injuries. Polytrauma patients may have concomitant fractures of the calcaneus, tibial plateau, acetabulum, spine, or long bones, resulting from one accident.

In assessing a specific joint injury, close attention should be paid to the soft-tissue envelope. Intraarticular fractures may cause gross malalignment of the limb, articular surface incongruity, or an associated joint subluxation or dislocation.

- All fractures have the potential to compromise blood circulation to the surrounding skin, or even the limb itself, so the vascular status distal to the injury must be evaluated. This is best done by palpation of the pulses distal to the injury.

If there are no palpable pulses or if a discrepancy exists between the injured and the contralateral side, the use of a Doppler monitor and assessment of capillary refill, color, and skin temperature are necessary. The ankle–brachial index (ABI) provides reliable objective information regarding arterial compromise following blunt or penetrating injury. An ABI of < 0.9 indicates a probable vascular injury [4]. A careful neurological examination of the limb must also be performed and documented. Prompt realignment and splintage of the limb prior to x-ray evaluation should be followed by a repeat neurological and vascular examination. Extensive open wounds, lacerations, or degloving are easily identified in the zone of injury. Even a small disruption of the skin near a fracture must be considered an open fracture, or an open joint injury, until proven otherwise. Leakage of bloodstained synovial fluid, fat globules in the blood, or leakage of intraarticularly injected fluid indicate that a fracture or joint injury communicates with the external environment.

In the absence of open wounds, extensive injury to the surrounding tissues can occur nevertheless.

- Determining the exact mechanism that caused the injury can help to predict the evolution of the soft-tissue injury.

The presence and location of any abrasions, joint effusion, skin blistering, and soft-tissue swelling should be noted. Point tenderness at ligamentous insertions may be the only clue to ligamentous disruption. Muscular compartments should be evaluated for any evidence of compartment syndrome. Both the AO and the Tscherne classification systems for closed injuries help to quantify the extent of soft-tissue damage (chapter 1.6). This is helpful in the development of a treatment plan. Following full evaluation, open wounds should be cleaned and dressed, antibiotics given as necessary, and the limb should be stabilized in a well padded splint, either by traction or with a temporary bridging external fixation device to reduce further swelling and potential additional soft-tissue compromise.

4 Evaluation of bone injury

Plain x-rays can provide a wealth of information regarding the injury to bone and offer clues about associated soft-tissue injury. They have traditionally been the most important tool available to the fracture surgeon for the assessment and treatment of fractures. Initial x-ray analysis includes two views obtained in planes 90° to each other and centered over the zone of injury (Fig 2.3-3a). The remainder of the limb will be examined by x-rays, if clinically indicated. To ensure adequate detail, the area of interest should not be covered by dense bandaging or splintage.
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Fig 2.3-3a–e X-ray/CT scan evaluation of the bone injury.

a Standard AP and lateral x-rays usually demonstrate the major fracture pattern, but show no details. Impaction of the joint surface can be assumed when there are irregularities of the subchondral lines and double densities in the metaphysis.

b Oblique views in two planes may give further evidence of the articular involvement and help to determine more precisely the extent and location of the lesion.

c–e Axial CT scans and 3-D reconstruction give the complete picture of a damaged joint and facilitate preoperative planning.
If there is extensive fragmentation and deformity, traction applied to the extremity during x-ray examination may improve understanding of the injury. Therefore, initial x-rays may require a physician in attendance to stabilize the limb and ensure that adequate images are obtained. For simple fractures, AP and lateral x-rays will suffice.

For more complex fractures, oblique x-rays taken at 45° to the coronal plane will help to identify fracture fragments (Fig 2.3-3b). Displacement and fragmentation of the articular and metaphyseal bone, identified by the plain standard views, can provide information about the bone quality and the amount of energy absorbed by the limb. Free articular fragments impacted into the supporting cancellous bone of the metaphysis can be identified by the density of their subchondral cortical bone (Fig 2.3-2a–b). As mentioned, these depressed fragments, without soft-tissue attachments, cannot be reduced to their original position by closed manipulation.

The identification of impacted fragments can have implications on the subsequent treatment of the fracture, since repositioning will require operative reduction.

The Müller AO Classification of fractures—long bones (chapter 1.5) categorizes fractures of the end segment of bone using standard terms to improve communication, develop treatment protocols, and to determine the outcome for specific injuries. The addition of computed tomography—along with 2-D and 3-D reconstruction—provides additional information about the number and position of the articular fragments, the presence of impacted articular segments, the location of metaphyseal fracture lines, and the overall morphology of the injury. This can be helpful in preoperative planning to determine surgical access, screw placement, and implant position (Fig 2.3-3c).

5 Scientific basis of treatment of articular fractures

Although the amount of energy absorbed by the bone can be evaluated with x-rays, the degree and extent of injury to the overlying hyaline cartilage cannot be judged with x-rays. Studies on the effects of impact load reveal that hyaline cartilage may fracture prior to bone, and a single impact can alter the biochemical composition of the cartilage matrix [5, 6]. Injury to the hyaline cartilage near or remote from the fracture can occur and has limited capacity for repair. Nevertheless, ample evidence suggests that articular cartilage can remain viable after blunt trauma [7, 8]. The role of direct injury to articular cartilage on the outcome of joint function and congruity has not yet been determined scientifically. Restoration of the articular surface following fracture in adults depends on early anatomical reconstruction, stable fixation with interfragmentary compression, and early motion (Fig 2.3-4). In cartilage defects associated with fracture of the subchondral bone, the repair with undifferentiated mesenchymal cells starts from the underlying bone. Small gaps or steps in the articular surface can “heal”, but in a high percentage of cases with fibrocartilage, which is of inferior mechanical resistance and less durable [9].

Mitchell and Shepard [10] demonstrated in animal experiments that anatomical reduction and stable fixation with interfragmentary compression of an intraarticular fracture, followed by continuous passive motion (CPM), leads to true hyaline cartilage healing.

Salter et al [9] demonstrated that transarticular immobilization after joint injury leads to stiffness and articular cartilage degeneration. It is assumed that this is due to a lack of nutrition and the formation of a destructive pannus. Further experiments revealed that the use of CPM facilitated the repair of full-thickness articular cartilage defects in immature rabbits.
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Pauwels [11] proposed that equilibrium exists between articular cartilage regeneration and degeneration, depending on the biomechanical environment of the joint. Articular cartilage is able to withstand a specific amount of force (F) per unit area (A), better defined as stress (S), that is S = F/A. If this stress exceeds a certain level for a period of time, articular cartilage may not be able to adapt and degeneration will result. Increases in stress on the articular cartilage can be secondary to axial malalignment of the bone, malalignment (steps or gaps) of the articular surfaces, or abnormal movements due to joint instability (Fig 2.3-5) [12].

Sensitivity to malalignment at the joint may be related to cartilaginous thickness and overall joint congruity. Finite element analysis has confirmed that a reduced cartilage thickness and high modulus of elasticity of cartilage increase the local contact stress caused by a standardized articular step. Experimental work [13] has also shown that articular cartilage and subchondral bone surfaces exhibit adaptive mechanisms that can restore or smooth the joint surface to improve load transmission with minor (2 mm) or full-thickness cartilaginous steps.

- Instability, caused by fracture, ligament, or meniscal injury can also lead to cartilage degeneration and may be important in determining outcome [14, 15]. Pauwels [11] proposed that anatomical restoration of the joint surfaces and mechanical axes are necessary for successful long-term outcome following a displaced articular fracture.

**Fig 2.3-4a–c**  Anatomical reconstruction of the joint surface combined with stable fixation allows early motion and distributes forces evenly across the joint, which is essential for a good long-term result.

a  Complete articular fracture of the distal tibia (43-C) in a ski instructor.

b  Exact reconstruction of the articular surface and stable fixation with the implants available in 1965. There was no cast applied but immediate functional postoperative treatment.

c  36 years later there are hardly any signs of arthritis and good function persists.
The tolerance to imperfection of an articular surface (steps or gaps) has not yet been determined for specific joints. The reasons range from an inability to reliably measure articular derangement following surgical reconstruction to the multiple confounding variables that may also lead to subsequent degeneration of the joint after injury. Although some authors have reported clinical studies showing that final functional and x-ray results depend on near anatomical reduction and early active joint motion [3, 16, 17], others have reported no correlation between articular surface reduction and clinical outcomes at an intermediate follow-up. This confusion exists despite many clinical examples that demonstrate that exact reconstruction and stable fixation may give functionally excellent and long-lasting results (Fig 2.3-4).

Most authors would agree that if morbidity after surgery can be minimized, anatomical reconstruction and stable fixation would most likely provide the individual patient with the best possible chance of permanent joint preservation. Large series of patients treated personally by one surgeon committed to the care of specific injuries will help the learning surgeon to understand what is surgically and clinically possible. Continuing education and adherence to protocols can help limit the incidence of complications and poor results. The principles of articular reconstruction delineated by Schatzker should be adhered to, even though we have learned much since that time regarding care of the soft-tissue envelope to help control associated complications.
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6 **Understanding the injury**

A thorough history of the mechanism of injury, the functional and work status prior to injury, and the patient’s expectations is required. Physical examination of the patient and limb is mandatory. Soft-tissue injury, especially swelling, blisters, abrasions, and/or lacerations must be assessed and documented. X-ray evaluation is performed so that the surgeon may understand the fracture pattern. The number and type of radiological investigations are determined by the surgeon’s need to fully understand the fracture so that a complete preoperative plan and surgical tactic can be designed.

7 **Principles of treatment**

7.1 **Preoperative planning**

Preoperative planning is an important prerequisite in open reduction and internal fixation of intraarticular fractures. Adequate x-ray analysis (Fig 2.3-3) together with the soft-tissue assessment will allow the surgeon to understand the “personality” of the injury and what will be needed to achieve the surgical goals. Deciding on the details of the procedure—the operating table, patient position, approach, specific instruments, implants, need for intraoperative x-ray—prior to commencing will allow the surgery to proceed more effectively and without the hazards of unforeseen problems (chapter 2.4).

- A detailed plan of the different steps and surgical tactic is mandatory before starting any osteosynthesis of an intraarticular fracture.

It also serves as an educational tool and may be used for quality control by the surgeon or his peers.

7.2 **Timing of surgery**

Following full evaluation of the patient and the specific injury, certain factors may influence a surgeon’s ability to intervene at a given time. In a patient with an isolated injury to a joint, the rapid onset of excessive swelling after injury is usually the result of hemorrhage into the joint and the surrounding tissues. Immediate surgery may allow evacuation of such a hematoma, while reduction and fixation will reduce further bleeding and possibly reduce further swelling. Therefore, the best time for early fracture fixation may be immediately after the injury.

- If the soft-tissue envelope around the joint is swollen or traumatized with abrasions or degloving, open surgery within the first few days may be contraindicated.

Early operative intervention of complex periarticular fractures of the lower extremity is time consuming and has been associated with an increase in wound healing complications [18]. Delaying surgery for several days may be more appropriate; however, temporary stabilization of the fracture by an external fixator spanning the joint, or traction may be helpful in preventing further soft-tissue damage and maintaining overall alignment. The external fixator should be placed outside the zone of injury and outside the zone of potential definitive surgery. Any delay in definitive fixation will be determined by the condition of the patient and the soft-tissue envelope. It is safe to operate when the skin in the area of the planned surgery has regained its creases and wrinkles.

Abrasions and blisters need to be epithelialized and dry before performing surgery near them. In case of a closed subcutaneous degloving or crushing of the subcutaneous fat, early operative debridement followed by a delayed articular reconstruction is recommended.
In polytraumatized patients it has been shown (chapter 4.1) that between days 2 and 3 after injury no planned surgery should be performed, while the best time for surgery is between days 5–10 (window of opportunity). Thereafter follows a period of immunosuppression, which again precludes planned surgery until week 3 when secondary reconstructions may be done. This may limit the surgeon’s ability to obtain anatomical restoration of the articular surface and axial alignment of the bone, which may influence long-term results [19].

Exceptions to delayed surgical intervention are open intraarticular fractures, which require at least a formal operative debridement, wound excision, irrigation, reconstruction and fixation of major articular fragments, and finally the closure of the joint. All osteochondral fragments should be retained, unless severely contaminated (chapter 4.2), so that they will be available for the definitive reconstruction. In the meantime, bridging of the joint by external fixation is recommended.

7.3 Surgical approach

For most limb injuries, skin incisions should be longitudinal, perpendicular to the axis of the joint, and not directly over any bony prominence. The possibility of future procedures should be kept in mind while planning the approach, although this consideration should not limit the access necessary for reduction and fixation. Skin incisions should be extensile for further exposure so as to limit tension on the skin during wound retraction. Skin has a rich vascular supply derived from the underlying fascia, and large cutaneous flaps must be avoided.

- Full-thickness fasciocutaneous flaps can be raised to allow mobilization of the soft tissues for improved access to the bone.

Once down to bone, care should be taken to avoid unnecessary stripping of any periosteal or soft-tissue attachments of the cortical fragments. Access to the joint can be accomplished either through fracture planes and associated rents in the articular capsule or through planned arthrotomies. Extensive stripping of capsule from articular bone fragments must be avoided in order to maintain their blood supply. Evacuation of hemarthrosis and any intraarticular debris is facilitated by copious irrigation of the joint. Traction applied to the limb can improve inspection of the joint surfaces.

7.4 Articular reconstruction and fixation

All fracture surfaces must be thoroughly cleared of hematoma and any early callus. Regardless of their size, all articular fragments should initially be retained as keys to the final reduction. Loose osteochondral fragments can be removed from the wound, but impacted fragments should not yet be elevated from their underlying cancellous beds. Once debris has been cleared, traction is reduced to allow the intact portions of the joint to resume their anatomical position. If there is inadequate stability, the large distractor, or an external fixator, may be used to maintain distraction and axial alignment and to allow some indirect reduction of fracture fragments (Fig 2.3-6a). The intact joint surfaces and the opposing articular surfaces are used as templates to judge the reduction of displaced or impacted articular fragments.

- Working through the fracture or through a window created in the metaphyseal cortex, central, impacted fragments can be elevated and reduced.

Impacted osteochondral fragments should be elevated from the underlying metaphyseal bone together with an adequate block of cancellous bone using an osteotome or elevator. This technique maintains the impacted zone between the subchondral cortical bone and its underlying cancellous bone, facilitating future fixation (Fig 2.3-6b).
Although free cartilage or osteochondral fragments without any cancellous bone support will be helpful in reducing major articular fragments, it may be difficult to retain and fix them reliably, and their long-term viability is questionable. They are therefore usually best removed after aiding in reduction.

- Bone defects left within the metaphysis can be filled with autogenous or allogenic bone grafts or bone substitutes to provide early structural support to the articular surface and to stimulate reconstitution of metaphyseal bone stock.

This may also provide support for the articular surface once weight bearing has been resumed. Cortex reduction and soft-tissue attachments will aid in reduction of peripheral fracture fragments and their associated articular surfaces.

Self-centering, pointed bone holding forceps or K-wires are temporarily used while the reduction is confirmed radiographically (Fig 2.3-6c).

In simple, partial articular split fractures, closed reduction may be attempted using the image intensifier or arthroscopy to check the reduction, followed by minimally invasive fixation with cannulated screws [20]. In the presence of intraarticular impaction and metaphyseal fragmentation (C3 injuries), no portion of the articular surface has any contact to the metaphysis. If initial reduction of the metaphysis provides a stable framework on which to build, the order of the procedure is reversed and a portion of the metaphysis is first reduced to the intact diaphysis. This will convert a C type injury into a B type partial articular injury.

**Fig 2.3-6a–d** Reconstruction of a tibial plateau 41-B3 fracture through a straight lateral parapatellar approach.

- Indirect reduction and axial alignment is achieved by ligamentotaxis and a joint bridging distractor.
- The large, impacted articular fragment is elevated with a curved impactor introduced through the fracture or through a cortical window in the metaphysis.
- After temporary fixation of the reduced fragment with a K-wire, the meta-/epiphyseal bone defect is filled with autogenous cancellous bone or a corticocancellous block acting as a strut.
- The reconstructed lateral plateau is finally buttressed by a conventional or locked plate. The K-wire has been replaced by a 6.5 mm cancellous bone lag screw.
Direct inspection of the joint surface, either through arthroto-
mies or arthroscopies, will help to evaluate the reduction of
the cartilaginous surfaces [21, 22]. Intraoperative image inten-
sification or x-rays will also provide information on reduction.
Once the reduction appears satisfactory, fixation of the intra-
articular portion can be completed (Fig 2.3-7). Lag screw
fixation creates compression between the fracture fragments
and results in stable fixation. If multiple small fragments are
present, reduction and support of the fracture without com-
pression can be maintained with fully threaded position
screws. In this instance, absolute stability may not be obtained
due to the small areas of fragment contact. Care must be taken
not to overcompress these fragments. A recently described
technique applies multiple 3.5 mm screws to the subchondral
bone to support fracture fragments. This “rafting technique”
is best used in a combination of locking head screws and a cor-
responding buttress plate. However, the effect of this stable
support on the local biology of the bone and cartilage is not yet
clear.

7.6 Soft-tissue reconstruction

Ligament injuries associated with articular fractures are fre-
quent but not always correctly diagnosed. Torn ligaments may
impede reduction (eg, deltoid ligament in malleolar fractures),
and depending on the joint involved, treatment will differ:
primary or secondary repair, or no repair at all. For more de-
tailed information we recommend referring to other chapters
of this book or to the literature.

Similarly, the meniscus of a joint may be involved, for ex-
ample in the knee, where the repair or reattachment of
the lateral meniscus is strongly recommended, as it will add to the
stability of the joint (chapter 6.8.1) [25].

7.5 Articular fractures with met-/diaphyseal extension

Once the articular block has been reconstructed anatomically
and fixed rigidly, the next task is to join it in the correct axial
and rotational alignment to the diaphysis. Exact reduction of
cortical fragments in the metaphysis is usually not necessary
if the area is not exposed. In order to start early movement of
the joint, this fixation must be stable, which is best obtained
by a long, bridging locking plate in buttress position and more
recently by specially designed intramedullary nails (eg, expert
nail system for proximal tibia (chapter 3.3.1:3.2; 3.3.1:3.3).
Larger cancellous bone defects may need some sort of bone
graft or bone substitute (Fig 2.3-6d).

Hybrid external fixators and ring fixators can be used with
limited surgical exposure of the meta-/diaphysis [23, 24]. A
significant part of the force is transmitted through the fixator,
and relative stability of the entire construction will be sufficient
to allow controlled early motion (chapter 3.3.3; 6.8.1; 6.8.3).

Fragmentation of the metaphysis or diaphysis may tempt a
surgeon to precisely reduce and internally fix all of the
nonarticular cortical fragments. Such exact reductions may
result in improved stability, but at the cost of biology (eg,
devascularization of fragments).

7.7 Postoperative treatment

The joint should be placed in a soft bulky bandage postopera-
tively. If stable fixation has been achieved, early postoperative
active-assisted exercises should be started under the supervi-
sion of a therapist. Isometric muscle exercises are started on
the first day following operation.

To maintain an optimal position of the extremity until muscle
control of joint motion is regained, the application of a re-
moveable splint may be justified. It will help soft-tissue recov-
er. Although the importance of early motion for cartilage
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Regeneration and ligament healing has been demonstrated, intermittent postoperative immobilization may be needed to ensure healing, especially when the compliance of the patient is doubtful, or when the fixation has not been optimal. Postoperative stiffness then becomes more likely. Limited weight bearing (10–15 kg) is prescribed typically for 6–8 weeks after surgery and can then be increased depending on the clinical aspect and x-rays. Full weight bearing should be delayed until about 3 months after injury.

Regular x-ray surveillance may help to detect a loss of reduction or fixation and will allow timely corrective intervention.

Fig 2.3-7a–k Open multifragmentary articular fracture of the distal humerus (13-C3). Temporary joint-spanning external fixator for damage control.

a  AP view.
b  Lateral view.
Open multifragmentary articular fracture of the distal humerus (13-C3).

The external fixator is removed before sterile draping of the patient. Further debridement of the wound follows. The joint fragments are cleaned. The articular fracture is reduced and the reduction is maintained with two 1.6 mm K-wires. A 3.5 mm cortex screw is inserted as a lag screw to maintain the reconstruction of the trochlea. Reduction of the lateral column to the joint should be performed first because of bone loss on the ulnar side.

The LCP reconstruction plates 3.5 are contoured. First one reconstruction plate is fixed to the posterior aspect of the lateral column with one locking head screw proximally and one distally. This allows the joint block to rotate slightly around the distal screw and facilitates the exact alignment of the medial supracondylar column.

The ulnar reconstruction plate is bent into its final shape and fixed to the shaft.

Final radiological control of plate position prior to wound closure.

At the end of the treatment, the patient had an unrestricted elbow flexion with a 10° extension deficit.

Heterotopic ossification, mainly at the posterior aspect, was excised at implant removal.
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8 Summary

The main principles of articular fracture management are to achieve an anatomical reduction and stable fixation of the joint surface as well as correct axial realignment of the limb. This will depend upon the condition of the patient and soft tissues. The overall management of an articular fracture requires considerable experience, a well designed preoperative plan, and a skillfully executed surgery, followed by appropriate postoperative treatment, in order to obtain the best outcome possible.

9 Bibliography
