

Hold

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surface Body weight Tension surface Ground re action Increase deformity and re stor e soft-tissue hinge Dorsal surface periosteum hinges Vo lar surface fails in tension Maximum displacement Close soft-tissue hinge With the injury force removed Hold position with the bones often recoil three-point /f_ i xation to bayonet apposition Figure 32.13 (a–d) Representation of how the mechanism of injury causes the bony and soft-tissue injury. (e–h) Representation of how the residual mechanical properties of the tissues may be used to effect and hold a reduction. Reduction has two components: reducing the fragments and assessing adequacy of reduction Reduction can be performed open or closed The principle is to reverse the movement that created the fracture Over-angulation allows the intact periosteum to guide the fragments into position

/uni25CF plates and screws; /uni25CF intramedullary nails. Note : Arthroplasty may be used where fragments cannot be held together. On occasion a combination of holding methods may be used; for example, K-wires and a moulded cast in the case of a simple extra-articular distal radial fracture. It is important to consider the way of holding the reduction in terms of outcome and ensure that this is part of the overarching goal to optimise the patient's return to function as safely and as fast as possible. For example, a displaced clavicle fracture in a 10-year old has a 99% chance of sound union within a few months if treated non-operatively . In contrast, a displaced multifragmen tary middle third clavicle in a 35-year-old woman will carry a 35% chance of going on to a non-union at 6 months. There fore, even though this fracture may heal with non-operative treatment, with appropriate explanation and shared decision making, a patient may choose to have surgery early in order to get back to normal function as soon as possible. Stability can be absolute or relative: /uni25CF Absolute stability . Implies no displacement or move ment and is achieved by accurate anatomical reduction with compression across the fracture fragments to optimise the environment for direct bone healing. This is desirable in intra-articular fractures, where callus at the fracture site might inhibit mov ement. Intra-articular fractures require an anatomical reduction and absolute stability . (a) (b) (c) Plaster of Paris is a white crystalline powder, calcium sulphate hemihydrate CaSO ture site, optimising the environment for callus formation and indirect bone

healing. Selected examples of achieving absolute and relative stability are shown in Figure 32.14. Plaster cast and splints Plaster casts and splints are generally used to hold stable fractures or supplement the fixation of unstable fractures (e.g. below-elbow cast applied to a distal radial fracture after K-wire fixation [see Kirschner wires]). Plaster casts come in two forms: plaster of Paris and synthetic casting materials. Plaster of Paris is the preferred method in acute fractures; where more support is needed, it is easier to mould plaster of Paris than a synthetic cast. In acute injuries, where there is a risk of swelling and compartment syndrome, a backslab will often be applied. A backslab is not always positioned on the dorsal surface as the name suggests, but is a partial cast where a layer of plaster of Paris or synthetic cast is applied along roughly half the circumference. An alternative to a backslab includes a full cast that is split along its full length to allow for swelling. The use of an incomplete cast does not remove the risk of swelling and compartment syndrome and must always be accompanied by close clinical observation. Moulding of the cast is an art form requiring appropriate skill to achieve the desired effect. Three-point moulding is used to control the position, often using the intact dorsal periodontal hinge to mould against (Figure 32.13). Often, a correctly (d) (e) (f) 0.5H₂O, which sets hard when water is added to it. 42

Absolute stability Lag screw Compression plating Compression with a ring fixator Figure 32.14 (a-f) How absolute and relative stability can be achieved. The same implants may be used to achieve different mechanical effects. Relative stability Bridge plating Intramedullary nail Bridging with a ring fixator

make straight bones' (Figure 32.15). Commercially available upper limb and lower limb splints provide comfort, support and social protection to stable fractures. Ease of application and the ability to remove them make them very useful for patients to return to activities of daily living, including bathing and showering. The advantages and disadvantages of plaster cast and splint usage are described in Table 32.4. Traction Traction is defined as a stretching force on a limb to pull a fracture straight. After appropriate pain control, simply pulling on the limb using manual traction will help realign fracture fragments, returning overall length and alignment. If the fracture is simple and off-ended (displaced so the two bone ends are translated and misaligned), it may require more than simply pulling to reduce it (see reduction in Figure 32.13). Once reduced, however, continued longitudinal traction will often hold it reduced. A traction force can be applied and maintained by a variety of systems and techniques. It is easy to apply traction to any extremity; however, it is cumbersome and requires a fixed point to pull on. This can require the patient to be fixed to one place and limit return to normal function (see Table 32.5 advantages and disadvantages of traction). Traction is often used in the treatment of femoral shaft fractures in adults as a temporary measure for comfort and to allow transfer of the patient, until definitive fixation can be undertaken. Hugh Owen Thomas, 1834-1891, general practitioner of Liverpool, UK, is regarded as the founder of orthopaedic surgery, although never holding a hospital appointment and preferring to treat patients in their own homes. He introduced the Thomas splint in 1875. A Thomas splint is applied to the limb initially in a static fashion (Figure 32.16a) and then, once in bed, balanced traction is applied to help pull the leg out to length and pull the splint off the ischial tuberosity (Figure 32.16b). (a) - for (b)

TABLE 32.4 Advantages and disadvantages of casting and splinting. Advantages No wound No interference with the fracture site Cheap Adjustable No implants to remove Disadvantages Limited access to the soft tissues Cumbersome (particularly in the elderly) Interferes with function Poor mechanical stability 'Plaster disease' – joint stiffness and muscle wasting

TABLE 32.5 Advantages and disadvantages of traction. Advantages No wound in zone of injury No interference with fracture site Materials cheap Adjustable Disadvantages Restricts mobility of patient Expensive in hospital time Skin pressure complications Pin site infection Thromboembolic complication

Figure 32.15 (a) The position achieved at the end of the manipulation described in Figure 32.13 . (b) Demonstration of how, by moulding the cast, the intact periosteum is kept under tension and the bone under compression; thus, the remaining mechanical properties are used to achieve stability.

Figure 32.16 (a) Static traction with a Thomas splint. The force and counterforce are contained within a static system. The load is applied to the patient through the tibial traction pin via a cord tightened with a Spanish windlass. The counterforce is applied through pressure by the splint on the ischial tuberosity. (b) A dynamic system in which the load is applied by weights suspended from the tibial pin and the counterforce is the patient's own weight.

applying an adhesive or non-adhesive bandage, or skeletal traction, where a pin is placed in the proximal tibia or distal femur. A common everyday example of traction is the use of a collar and cuff in proximal humeral fractures. When the patient is upright, the lower part of the arm, under the action of gravity, provides longitudinal traction, thus aligning the fracture fragments.

Kirschner wires Kirschner wires (also called K-wires) are smooth, non-threaded, thin flexible wires often between 0.9 and 2.5 mm in diameter. They are used to hold small fragments in place. They may be used in a temporary fashion intraoperatively to hold fracture fragments in place until definitive fixation with plates and screws can be performed. They are inexpensive and simple to use. Moreover, they are extensively used for definitive fixation of injuries around the hand and wrist. The flexible nature of the wires can often require supplementation, as a hybrid construct of K-wires and plaster cast fixation. In distal radial fractures the wires are placed percutaneously after closed reduction, with the trailing end of the wire left proud of the skin and the end bent to limit wire migration. K-wires around the distal radius can be removed in the clinic setting 4–6 weeks after insertion. Complications of K-wires include pin site infection, wire breakage, loss of fixation and

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J Charles Taylor, orthopaedic surgeon, Memphis, TN, USA. A common problem in certain locations. It is not advisable to use non-threaded K-wires around the shoulder girdle and clavicle as migration into the thoracic cavity and heart has been reported (Table 32.6).

External fixation External fixation involves percutaneous placement of metal rods or fine wires into bone to anchor a metal frame on the outside (Table 32.7). The frame construct itself may consist of tubular rods with connectors, or a circular ring construct – the 'Ilizarov' frame. Hybrid variations are infinite, with combinations of anchor fixation modalities and frame constructs. The Taylor spatial frame allows for gradual correction of deformity – (Figure 32.17). The major drawback of external fixation is that they can be cumbersome to the patient and pin site infection can be a problem (Table 32.7). Specific indications for external fixators include:

(a) (b) Figure 32.17 (a) Monolateral tubular frame with a metal rod (half pin anchorage to bone). (b) Monolateral tubular frame with a metal rod (half pin anchorage to bone). (c) Hybrid circular/tubular rod frame construct with a combination of half pin and fine wire

anchorage to bone. allows for gradual correction of deformity. TABLE 32.6 Indications for K-wire insertion. Temporary fixation Debridement fixation – with small fracture fragments (e.g. wrist fractures and hand injuries) Tension band wiring (fractures of the patella and olecranon) Temporary immobilisation of a small joint (c) (d) (b) Circular ring fixator with fine wire anchorage to (d) Taylor spatial frame;

emergency stabilisation of a long bone fracture in the poly trauma patient thought too unwell to have other interventions – damage control orthopaedics; stabilisation of a dislocated joint after reduction (e.g. a spanning fixator across the knee joint while the vascular surgeons repair an arterial injury with a knee dislocation); complex periarticular fractures to provide temporary stabilisation and allow the soft-tissue damage to recover before definitive fixation (e.g. a distal tibial [pilon] fracture); fractures associated with infection; treating fractures with bone loss. Plates and screws Plates and screws can be used in many different ways. A ‘lag screw’ can be used to generate compression across a fracture site, optimising the environment for direct bone healing. Similarly, compression can be achieved using a dynamic compression plate. A plate might also be used simply to neutralise forces, buttress a fracture or work as an internal-external fixator (Figure 32.14). In general, plates and screws are used where possible in articular and periarticular fractures where an anatomical reduction is required, often via open means, followed by the application of the plate and screws to achieve a rigid construct. In extra-articular fractures, where mechanical alignment is required together with relative stability, one option is the use of locking plate technology. This allows a closed reduction and percutaneous placement of the plate with locking screws to create an internal construct, which behaves like an external fixator. Injury-specific plating systems have revolutionised the orthopaedics. Plates are shaped for specific anatomical regions and specific injury patterns (see Table 32.8 for the advantages and disadvantages of plate fixation). Intramedullary nails Diaphyseal fractures are best suited for intramedullary nailing. Where mechanical alignment is required together with relative stability, they allow for indirect bone healing. After nail insertion, mechanical alignment is checked particularly for length, alignment and rotation. Locking screws are then placed proximally and distally to maintain length and alignment. Intramedullary nailing of metaphyseal and articular fractures is a challenge. However, with improved implant design and the ability to lock the nails very distally and in multiple directions, the indications for intramedullary nailing are expanding. Intramedullary nails may be placed in an unreamed or reamed fashion. Reaming is the process whereby the intramedullary canal is widened slightly to allow passage of a larger diameter nail, relating to the last reamer size used. Table 32.9 - compares reamed with unreamed nails. Intramedullary nailing can be a technically demanding procedure. The advantages and disadvantages are summarised in Table 32.10. Arthroplasty Arthroplasty is indicated in certain acute circumstances: articular fractures that are not reconstructible or injuries where the vascularity of the articular segment is compromised (e.g. displaced intracapsular femoral neck fracture in an older patient).

fixation. Advantages No interference with fracture site Adjustable after application: alignment; biomechanics Soft tissues accessible for plastic surgery Rapid stabilisation of fracture Hardware easy to remove Disadvantages Pin site infection Interferes with plastic surgical procedures Soft-tissue tethering Cumbersome for the patient TABLE 32.8 Advantages and disadvantages of plate

and screw fixation. Advantages Can be used when anatomical reduction is required Allows early mobilisation Can provide absolute or relative stability Disadvantages May interfere with the fracture site Periosteal/soft-tissue damage Does not normally allow for immediate load-bearing Potential for infection Metalwork complications Possible need for plate removal

TABLE 32.9 A comparison of reamed and unreamed nailing (an assumption is that nails used unreamed are usually thinner than those used reamed).

	Reamed IMN	Unreamed IMN
Insertion time	Longer	Quicker
Time to union	Shorter	Longer
Size of implant	Larger	Smaller
Reduction of distal	Easier	More difficult
Strength of construct	More	Less

IMN, intramedullary nail. TABLE 32.10 Advantages and disadvantages of intramedullary nailing.

	Advantages	Disadvantages
	Minimally invasive	Early weight-bearing
	Less periosteal damage than open reduction and internal fixation	Seldom need removal
	Increased risk of fat emboli/chest complications	Infection difficult to treat
	Difficult to remove if broken	

to be considered in choosing arthroplasty as a treatment option. Implant longevity and level of activities following implant insertion need to be matched. Traditionally, arthroplasty for trauma was limited to hip and shoulder hemiarthroplasty. Total hip replacement, acute distal femoral replacement, radial head replacement, total and hemielbow arthroplasty and reverse polarity shoulder arthroplasty are current treatment options for older patients with osteoporotic periarticular fractures. The selection of a particular technique will depend on clinical evidence and our previously stated aim to return patients to optimal function as soon as possible. It should be considered in the context that it can be expensive and require considerable other resources to make the procedure safe and long-lasting. Hold

If the fracture fragments are in an acceptable position, or have been reduced into an acceptable position, they then need to be held in that position until they heal. When choosing a method to hold a fracture the aim is to: optimise the biological and mechanical environment to create the most favourable conditions possible for fracture healing; Martin Kirschner, 1879–1942, Professor of Surgery, Heidelberg, Germany, introduced the use of skeletal traction wires in 1909.

(f) (b) (c) (g) . (d) (h) - - Summary box 32.4 - Reduction

optimise the biological and mechanical environment to create the most favourable conditions possible for fracture healing; minimise the period of disability by speeding up the healing process or providing enough stability to return to normal function while the fracture heals. There are several methods of holding fracture fragments in place: plaster cast/splints; traction; Kirschner (K-) wires;

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Absolute stability. Implies no displacement or movement and is achieved by accurate anatomical reduction with compression across the fracture fragments to optimise the environment for direct bone healing. This is desirable in intra-articular fractures, where callus at the fracture site might inhibit movement. Intra-articular fractures require an anatomical reduction and absolute stability.

(a) (b) (c) Plaster of Paris is a white crystalline powder, calcium sulphate hemihydrate $\text{CaSO}_4 \cdot 0.5\text{H}_2\text{O}$, which sets hard when water is added to it. Optimising the environment for callus formation and indirect bone healing. Selected examples of achieving absolute and relative stability are shown in Figure 32.14.

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Traction is often used in the treatment of femoral shaft fractures in adults as a temporary measure for comfort and to allow transfer of the patient, until definitive fixation can be undertaken. A Thomas splint is applied to the limb initially in a static fashion (Figure 32.16a) and then, once in bed, balanced traction is applied to help pull the leg out to length and pull the splint off the ischial tuberosity (Figure 32.16b).

TABLE 32.4 Advantages and disadvantages of casting and splinting.

Advantages	Disadvantages
No wound interference with the fracture site	Limited access to the soft tissues
Cheap	Cumbersome (particularly in the elderly)
Adjustable	Interferes with function
No implants to remove	Poor mechanical stability
	'Plaster disease' - joint stiffness and muscle wasting

TABLE 32.5 Advantages and disadvantages of traction.

Advantages	Disadvantages
No wound in zone of injury	Restricts mobility of patient
No interference with fracture site	Expensive in hospital time
Materials cheap	Skin pressure complications
Adjustable	Pin site infection
	Thromboembolic complication

Figure 32.15 (a) The position achieved at the end of the manipulation described in Figure 32.13. (b) Demonstration of how, by moulding the cast, the intact periosteum is kept under tension and the bone under compression; thus, the remaining mechanical properties are used to achieve stability.

Figure 32.16 (a) Static traction with a Thomas splint. The force and counterforce are contained within a static system. The load is applied to the patient through the tibial traction pin via a cord tightened with a Spanish windlass. The counterforce is applied through pressure by the splint on the ischial tuberosity. (b) A dynamic system in which the load is applied by weights suspended from the tibial pin and the counterforce is the patient's own weight.

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emergency stabilisation of a long bone fracture in the poly trauma patient thought too unwell to have other interven tions - damage control orthopaedics; stabilisation of a dislocated joint after reduction (e.g. a spanning fixator across the knee joint while the vascular surgeons repair an arterial injury with a knee dislocation); complex periarticular fractures to provide temporary stabi lisation and allow the soft-tissue damage to recover before definitive fixation (e.g. a distal tibial [pilon] fracture); fractures associated with infection; treating fractures with bone loss. Plates and screws Plates and screws can be used in many di ff erent ways. A 'lag screw' can be used to generate compression across a fracture site, optimising the environment for direct bone healing. Similarly , compression can be achieved using a dynamic compression plate. A plate might also be used simply to neutralise forces, buttress a fracture or work as an internal-external fixator (Figure 32.14). In general, plates and screws are used where possible in articular and periarticular fractures where an anatomical reduction is required, often via open means, followed by the application of the plate and screws to achie ve a rigid construct. In extra-articular fractures, where mechanical alignment is required together with relative stability , one option is the use of locking plate technology . This allows a closed reduction and percutaneous placement of the plate with locking screws to create an internal construct, which behaves like an external fixator. Injury-specific plating systems have revolutionised the /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF shaped for specific anatomical regions and specific injury pat - terns (see Table 32.8 for the advantages and disadvantages of plate fixation). Intramedullary nails Diaphyseal fractures are best suited for intramedullary nailing. Where mechanical alignment is required together with rela - tive stability , they allow for indirect bone healing. After nail insertion, mechanical alignment is checked particularly for length, alignment and rotation. Locking screws are then placed pro ximally and distally to maintain length and alignment. Intramedullary nailing of metaphyseal and articular fractures is a challenge. However, with

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Arthroplasty Arthroplasty is indicated in certain acute circumstances: articular fractures that are not reconstructible or injuries where the vascularity of the articular segment is compromised (e.g. displaced intracapsular femoral neck fracture in an older patient).

Table 32.8 Advantages and disadvantages of plate and screw fixation.

Advantages	No interference with fracture site	Adjustable after application: alignment; biomechanics	Soft tissues accessible for plastic surgery	Rapid stabilisation of fracture	Hardware easy to remove
Disadvantages	Pin site infection	Interferes with plastic surgical procedures	Soft-tissue tethering	Cumbersome for the patient	

Table 32.9 A comparison of reamed and unreamed nailing (an assumption is that nails used unreamed are usually thinner than those used reamed).

Reamed IMN	Unreamed IMN	Insertion time	Longer
Quicker	Time to union	Shorter	Longer
Size of implant	Larger	Smaller	Reduction of distal
Easier	More difficult fractures	Strength of construct	More
Less	IMN, intramedullary nail.		

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Advantages	Minimally invasive	Early weight-bearing	Less periosteal damage than open reduction and internal fixation	Seldom need removal
Disadvantages	Increased risk of fat emboli/chest complications	Infection	Difficult to treat	Difficult to remove if broken

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/uni25CF plates and screws; /uni25CF intramedullary nails. Note : Arthroplasty may be used where fragments cannot be held together. On occasion a combination of holding methods may be used; for example, K-wires and a moulded cast in the case of a simple extra-articular distal radial fracture. It is important to consider the way of holding the reduction in terms of outcome and ensure that this is part of the overarching goal to optimise the patient's return to function as safely and as fast as possible. For example, a displaced clavicle fracture in a 10-year old has a 99% chance of sound union within a few months if treated non-operatively . In contrast, a displaced multifragmentary middle third clavicle in a 35-year-old woman will carry a 35% chance of going on to a non-union at 6 months. Therefore, even though this fracture may heal with non-operative treatment, with appropriate explanation and shared decision making, a patient may choose to have surgery early in order to get back to normal function as soon as possible. Stability can be absolute or relative: /uni25CF Absolute stability . Implies no displacement or movement and is achieved by accurate anatomical reduction with compression across the fracture fragments to optimise the environment for direct bone healing. This is desirable in intra-articular fractures, where callus at the fracture site might inhibit movement. Intra-articular fractures require an anatomical reduction and absolute stability . (a) (b) (c) Plaster of Paris is a white crystalline powder, calcium sulphate hemihydrate CaSO₄·0.5H₂O, which sets hard when water is added to it. 4 2

Absolute stability Lag screw Compression plating Compression with a ring /f_i xator Figure 32.14 (a-f) How absolute and relative stability can be achieved. The same implants may be used to achieve different mechanical effects. Relative stability Bridge plating Intramedullary nail Bridging with a ring /f_i xator

make straight bones' (Figure 32.15). Commercially available upper limb and lower limb splints provide comfort, support and social protection to stable frac tures. Ease of application and the ability to remove them make them very useful for patients to r eturn to activities of daily living, including bathing and showering. The advantages and disadvantages of plaster cast and splint usage are described in Table 32.4 . /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF Traction Traction is defined as a stretching force on a limb to pull a fracture straight. After appropriate pain control, simply pulling on the limb using manual traction will help realign fracture fragments, returning overall length and alignment. If the fracture is simple and o ff -ended (displaced so the two bone ends are translated and misaligned), it may require more than simply pulling to reduce it (see reduction in Figure 32.13 Once reduced, however, continued longitudinal traction will often hold it reduced. A traction force can be applied and maintained by a vari ety of systems and techniques. It is easy to apply traction to any extremity; however, it is cumbersome and requires a fixed point to pull on. This can require the patient to be fixed to one place and limit r eturn to normal function (see Table 32.5 advantages and disadvantages of traction). /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF Traction is often used in the treatment of femoral shaft fractures in adults as a temporary measure for comfort and to allow transfer of the patient, until definitive fixation can be Hugh Owen Thomas , 1834–1891, general practitioner of Liverpool, UK, is regarded as the founder of orthopaedic surgery , although never holding a hospital appointment and preferring to treat patients in their own homes. He introduced the Thomas splint in 1875. - (b) undertaken. A Thomas splint is applied to the limb initially in a static fashion (Figure 32.16a) and then, once in bed, balanced traction is applied to help pull the leg out to length and pull the splint o ff the ischial tuberosity (Figure 32.16b).). (a) - for (b)

TABLE 32.4 Advantages and disadvantages of casting and splinting. Advantages No wound No interference with the fracture site Cheap Adjustable No implants to remove Disadvantages Limited access to the soft tissues Cumbersome (particularly in the elderly) Interferes with function Poor mechanical stability 'Plaster disease' – joint stiffness and muscle wasting TABLE 32.5 Advantages and disadvantages of traction. Advantages No wound in zone of injury No interference with fracture site Materials cheap Adjustable Disadvantages Restricts mobility of patient Expensive in hospital time Skin pressure complications Pin site infection Thromboembolic complication Figure 32.15 (a) The position achieved at the end of the manipulation described in Figure 32.13 . (b) Demonstration of how, by moulding the cast, the intact periosteum is kept under tension and the bone under compression; thus, the remaining mechanical properties are used to achieve stability. ight We Figure 32.16 (a) Static traction with a Thomas splint. The force and counterforce are contained within a static system. The load is applied to the patient through the tibial traction pin via a cord tightened with a Spanish windlass. The counterforce is applied through pressure by the splint on the ischial tuberosity. (b) A dynamic system in which the load is applied by weights suspended from the tibial pin and the counterforce is the patient's own weight.

applying an adhesive or non-adhesive bandage, or skeletal traction, where a pin is placed in the proximal tibia or distal femur. A common everyday example of traction is the use of a collar and cuff in proximal humeral fractures. When the patient is upright, the lower part of the arm, under the action of gravity, provides longitudinal traction, thus aligning the fracture fragments. Kirschner wires (also called K-wires) are smooth, non-threaded, thin flexible wires often between 0.9 and 2.5 mm in diameter. They are used to hold small fragments in place. They may be used in a temporary fashion intraoperatively to hold fracture fragments in place until definitive fixation with plates and screws can be performed. They are inexpensive and simple to use. Moreover, they are extensively used for definitive fixation of injuries around the hand and wrist. The flexible nature of the wires can often require supplementation, as a hybrid construct of K-wires and plaster cast fixation. In distal radial fractures the wires are placed percutaneously after closed reduction, with the trailing end of the wire left proud of the skin and the end bent to limit wire migration. K-wires around the distal radius can be removed in the clinic setting 4–6 weeks after insertion. Complications of K-wires include pin site infection, wire breakage, loss of fixation and migration.

Gavriil Abramovich Ilizarov, 1921–1993, orthopaedic surgeon, Kurgan, Western Siberia, Russia. He did not attend school until he was 11 years old as his family was too poor to buy him shoes. J Charles Taylor, orthopaedic surgeon, Memphis, TN, USA. His problem in certain locations. It is not advisable to use non-threaded K-wires around the shoulder girdle and clavicle as migration into the thoracic cavity and heart has been reported (Table 32.6).

External fixation External fixation involves percutaneous placement of metal rods or fine wires into bone to anchor a metal frame on the outside (Table 32.7). The frame construct itself may consist of tubular rods with connectors, or a circular ring construct – the ‘Ilizarov’ frame. Hybrid variations are infinite, with combinations of anchor fixation modalities and frame constructs. The Taylor spatial frame allows for gradual correction of deformity – (Figure 32.17). The major drawback of external fixation is that they can be cumbersome to the patient and pin site infection can be a problem (Table 32.7). Specific indications for external fixators include:

- (a) Monolateral tubular frame with a metal rod (half pin anchorage to bone).
 - (b) Circular ring fixator with fine wire anchorage to bone.
 - (c) Hybrid circular/tubular rod frame construct with a combination of half pin and fine wire anchorage to bone. allows for gradual correction of deformity.
- TABLE 32.6 Indications for K-wire insertion.
- Temporary fixation of small fracture fragments (e.g. wrist fractures and hand injuries)
 - Tension band wiring (fractures of the patella and olecranon)
 - Temporary immobilisation of a small joint
 - (d) Taylor spatial frame;

emergency stabilisation of a long bone fracture in the poly trauma patient thought too unwell to have other interventions – damage control orthopaedics; stabilisation of a dislocated joint after reduction (e.g. a spanning fixator across the knee joint while the vascular surgeons repair an arterial injury with a knee dislocation); complex periarticular fractures to provide temporary stabilisation and allow the soft-tissue damage to recover before definitive fixation (e.g. a distal tibial [pilon] fracture); fractures associated with infection; treating fractures with bone loss. Plates and screws Plates and screws can be used in many different ways. A ‘lag screw’ can be used to generate compression across a fracture site, optimising the environment for direct bone healing. Similarly, compression can be achieved using a dynamic

compression plate. A plate might also be used simply to neutralise forces, buttress a fracture or work as an internal-external fixator (Figure 32.14). In general, plates and screws are used where possible in articular and periarticular fractures where an anatomical reduction is required, often via open means, followed by the application of the plate and screws to achieve a rigid construct. In extra-articular fractures, where mechanical alignment is required together with relative stability , one option is the use of locking plate technology . This allows a closed reduction and percutaneous placement of the plate with locking screws to create an internal construct, which behaves like an external fixator. Injury-specific plating systems have revolutionised the /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF shaped for specific anatomical regions and specific injury patterns (see Table 32.8 for the advantages and disadvantages of plate fixation). Intramedullary nails Diaphyseal fractures are best suited for intramedullary nailing. Where mechanical alignment is required together with relative stability , they allow for indirect bone healing. After nail insertion, mechanical alignment is checked particularly for length, alignment and rotation. Locking screws are then placed proximally and distally to maintain length and alignment. Intramedullary nailing of metaphyseal and articular fractures is a challenge. However, with improved implant design and the ability to lock the nails very distally and in multiple directions, the indications for intramedullary nailing are expanding. Intramedullary nails may be placed in an unreamed or reamed fashion. Reaming is the process whereby the intramedullary canal is widened slightly to allow passage of a larger diameter nail, relating to the last reamer size used. Table 32.9 compares reamed with unreamed nails. Intramedullary nailing can be a technically demanding procedure. The advantages and disadvantages are summarised in Table 32.10 .

Arthroplasty Arthroplasty is indicated in certain acute circumstances: articular fractures that are not reconstructible or injuries where the vascularity of the articular segment is compromised (e.g. displaced intracapsular femoral neck fracture in an older patient).

Fixation. Advantages No interference with fracture site Adjustable after application: alignment; biomechanics Soft tissues accessible for plastic surgery Rapid stabilisation of fracture Hardware easy to remove Disadvantages Pin site infection Interferes with plastic surgical procedures Soft-tissue tethering Cumbersome for the patient

TABLE 32.8 Advantages and disadvantages of plate and screw fixation. Advantages Can be used when anatomical reduction is required Allows early mobilisation Can provide absolute or relative stability Disadvantages May interfere with the fracture site Periosteal/soft-tissue damage Does not normally allow for immediate load-bearing Potential for infection Metalwork complications Possible need for plate removal

TABLE 32.9 A comparison of reamed and unreamed nailing (an assumption is that nails used unreamed are usually thinner than those used reamed). Reamed IMN Unreamed IMN Insertion time Longer Quicker Time to union Shorter Longer Size of implant Larger Smaller Reduction of distal Easier More difficult fractures Strength of construct More Less IMN, intramedullary nail.

TABLE 32.10 Advantages and disadvantages of intramedullary nailing. Advantages Minimally invasive Early weight-bearing Less periosteal damage than open reduction and internal fixation Seldom need removal Disadvantages Increased risk of fat emboli/chest complications Infection difficult to treat Difficult to remove if broken

to be considered in choosing arthroplasty as a treatment option. Implant longevity and level of activities following implant insertion need to be matched. Traditionally , arthroplasty for trauma was limited to hip and shoulder hemiarthroplasty . Total hip replacement, acute distal femoral replacement, radial head replacement, total and hemielbow arthroplasty and reverse polarity

shoulder arthroplasty are current treatment options for older patients with osteoporotic periarticular fractures. The selection of a particular technique will depend on clinical evidence and our previously stated aim to return patients to optimal function as soon as possible. It should be considered in the context that it can be expensive and require considerable other resources to make the procedure safe and long-lasting.

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