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Types of internal fixation

Indications Principles of Internal Fixation Types of Internal Fixation Complications Failure to obtain or maintain fracture reduction 1. Irreducible fractures Fractures that cannot be reduced except by operation 2. Unstable fractures Fractures that are inherently unstable & prone to redisplacement after reduction 3. Fractures that unite poorly Principally fractures of the femoral neck 4. Pathological fractures Fractures in which bone disease may prevent healing 5. Multiple fractures Where fixation of one fracture facilitates treatment of the others 6. Fractures in patients who present nursing difficulties Eg. paraplegics, multiply injured patients, elderly The aim of treatment is to produce stable fracture fixation, with a minimum of devascularisation, & early motion & partial loading Principles (AO) 1. Anatomical reduction of the fracture fragments, particularly articular 2. Stable internal fixation 3. Preservation of the blood supply dependent on surgical technique 4. Early active pain-free mobilisatio of muscle & joints (reduces joint contracture & loss of motion & dystrophy) Stable fixation Fixation that prevents motion of the fragments Stable fixation is best represented by a simple fracture with a rigid plate applied across the fracture in compression Introduction of compression introduced stability Compression allows the transfer of force from fragment to fragment rather than via the implant Stable fixation restores the load bearing capacity Compression 2 effects Produces preloading, maintaining close contact of the fragment surfaces Produces friction which resists transverse displacement & torque about the long axis Strain Relative deformation of a tissue > Displacement of fragments divided by the width of the fracture gap Represents the degree of instability At very low levels of strain the bone heals by primary healing At intermediate levels healing is by callus At high levels nonunion occurs Instability is best tolerated by multifragmentary fractures because the displacement is distributed over several interfaces & the individual strain is low Strain is very high for bone fragments separated by a single narrow gap & these fractures are very intolerant of even minute displacement This explains why in some situations where mobility has not been abolished (intramedullary nailing) the fracture heals while in other instances where only a very small gap is left even macroscopically invisible movement is not tolerated natural healing of bone tends to follow these principles in that concentric callus is formed about the fracture site producing a mechanical advantage & as the tissue differentiates a more rigid approximation of the fracture occurs At the same time resorption of the fracture ends occurs widening the interfragment gap & decreasing the strain value Types of Internal Fixation 1. Lag screws 2. Plates 3. Intramedullary Nails 4. Tension Band Wiring Lag Screws Stability is achieved by compression & bone contact Load transfer occurs directly from fragment to fragment & not via the implant Should be placed perpendicular to the fracture line Screw can apply 2000-4000N Drilling & insertion of a lag screw stimulates bone formation around the threads & maximum strength is reached at 6-8 weeks & at all times remains higher than when inserted One screw is never strong enough to achieve stable fixation & 2-3 screws are required Plates Seven types 1. Neutralisation plate 2. Compression plate 3. Buttress plate 4. Bridging plate/ wave plate 5. Antiglidle plate 6. Tension-band plate 7. Spring plate Neutralisation Plate Protect lag screws from bending, shear, & rotation Eg. lateral malleolus fracture Compression plate Applied to tension side of eccentrically loaded bone Can produce 600N compression (cf. 2000-4000N compression with lag screw) Plate should be overbent to produce compression on far side as well as near cortex Inner screws applied first Function of grooves on LCDCP Improve blood circulation by minimising plate-bone contact More even distribution of stiffness through the plate Allows small bone bridge beneath the plate Eg. transverse or short oblique radial fracture Buttress plate Physically protects underlying thin cortex Often for metaphyseal fractures Eg. tibial plateau & distal radius fractures Bridging plate Treatment of multifragmented fractures Bridge segment of comminution with indirect reduction & minimal disruption to blood supply Compression occasionally possible Eg. comminuted ulnar fracture Antiglidle plate Secured at apex of fragment of oblique fracture to physically block shortening or displacement Eg. Weber B ankle fracture with posterior plate Tension-band plate Same principle as TBW with application on tensile surface of eccentrically loaded bone & conversion of tension forces to compression forces Eg. olecranon plate Number of cortices Humerus 6 Radius & ulna 5 Femur 7 Tibia 6 Intramedullary Nail Fixation of diaphyseal fractures of long bones Types Reamed vs Unreamed Cylindrical vs Slotted Locked vs Unlocked Anterograde vs Retrograde Examples Humeral nails Forsythe nails Femoral & tibial nails Long Gamma nails Expandable nails Hollow nails associated with higher incidence of infection? Tension-band Wiring Relies upon compression by the dynamic component of the functional load Conversion of tension forces to compression forces Allows some load-induced movement Patella & olecranon fractures Bioabsorbable Materials Poly-lactic acid (PLA) Not induce bone reaction ~ 2 years to resorb Screws & wires available Poly-glycolic acid (PGA) Associated with cyst formation ? not used anymore Complications Infection Nonunion Patient factors Injury factors Bone factors Surgical factors Implant failure Refracture Share This Page with Your Peers and Friends Internal fixation of the bone is a type of fixation where the fixing device is not exposed to outside environment as it is buried under the soft tissue. This is in contrast to external fixation. Bone acts as a supporting structure and transmits load. Different forces that act on bone are compression, tension and shear. Bone is strongest in compression and weakest in tension. Most of the compression fractures are therefore seen in cancellous bones like metaphyses, vertebral bodies, and the calcaneus. Transverse, oblique, and spiral are the common fracture pattern seen in cortical bones. [Read more on types of fractures] Biology of Fracture Healing Fracture leads to disruption of the endosteal and periosteal blood supply and leads to an inflammatory reaction which attracts bone forming mediators and cells. The inflammation stage begins soon after injury and appears clinically as swelling, pain, and erythema. Fracture hematoma prompts the migration of inflammatory cells, which stimulate angiogenesis and cell proliferation. After the initial inflammatory phase, the soft callus stage begins with an infiltration of fibrous tissue and chondroblasts surrounding the fracture site. Soft callus formation adds to the structural stability of the fracture site. Soft callus is then converted into rigid bone, the hard callus stage, by bone ossification. At this point, the fracture is declared united. Remodeling is the process by which woven bone is replaced by the lamellar bone. It takes more than a year for the fracture site to remodel. [Read more on fracture healing] Significance and Need for Internal Fixation Clinical Photograph During Surgery Showing Well Contoured Anatomical Plate When a bone is fractured, it loses its structural continuity which makes it unable to bear any load. There is also a soft tissue injury component which varies with the severity of the injury. Damage to the soft tissues and of the stiffness of neighboring joints are responsible for long-term morbidity. Earlier, all fractures were treated with prolonged immobilization in plaster casts/splints. Stiffness in adjacent joints was a known complication especially in fractures near the joint. It happens because prolonged immobilization leads to atrophy of the articular cartilage, to capsular and ligamentous contractures, and gives rise to intra-articular adhesions. Tethering effect of soft tissues further adds to the effect. This loss of function due to scarring and secondary joint stiffness can only be prevented by early mobilization. Thus, modern fracture treatment aims at the restoration of function of the soft tissues and adjacent joints and not bone union at the expense of function. The idea behind the changed paradigm is that it is easier to correct a non-union or deformity in presence of good soft tissue envelope but the scarring, obliteration of the soft tissue gliding planes, and joint stiffness are often permanent. The function is more important than a union which is considered of secondary importance. This highlights the importance of early fixation of fractures. Early fixation of fractures enables early joint mobilization and strength maintaining exercises. A bony issue if present could be dealt with later. [This concept of early function has been included in modern plaster treatment as well – functional fracture treatment which makes use of specialized splinting of the bone in special braces that allow an early return of function and motion. But there is a limitation to this method and a lot of fracture pattern are better served by fracture fixation especially internal fixation of fractures especially intra-articular and periarticular fractures.] A stable internal fixation abolishes fracture pain and allows early joint motion [and weight bearing in selected cases] and reducing the need for prolonged rehabilitation period. Stable fixation also restores load-bearing capacity to bone. With stable fixation, both cancellous and cortical fragments heal by primary bone healing. [Read and compare other type of fixation – the external fixation] Methods of Internal Fixation Screws Representative image, this screw is probably not a bone screw, presented to highlight the concept of pitch AP View Fracture of Lateral Condyle of Humerus Fixed With Cannulated Screws Hoffa fracture fixed with cancellous screws and Herbert Screws Lag screws are used to achieve compression across the fracture fragments and are useful in case of a large third fragment in transverse fractures [butterfly fragment], spiral fractures, oblique fractures, and intra-articular fractures. Interfragmental compression results in impaction of the fragments and in a marked increase in frictional resistance to motion. At the same time, it also reduces greatly the force transmission. It also greatly diminishes the forces borne by an internal fixation device. Compression and establishment of bone contact are essential for stable internal fixation. Lag screw offers the simplest method of compressing two fragments of bone and is a very efficient implant in use for securing interfragmental compression. In order to exert the most efficient degree of interfragmental compression, lag screws must be inserted into the center of fragments and at right angles to the fracture plane. A minimum of two, and preferably three screws are required for stable compression. Interfragmentary screw fixation of a fracture In fractures of phalanges, metacarpals, metatarsals, or malleoli, lag screws can be used alone. But they are not sufficient for the fixation of long bones such as the femur or the humerus. In these bones, they need to be combined with plates that protect the screw fixation from mechanical overload. [Read more about Bone Screws] Plating Volar Plating For Distal Radius Fracture – Peroperative Photo Plating is a broad term for fracture fixation using plate and screws. There are many modes in which plates can be used to fix a fracture Neutralization plates or protection plates are used to protect the primary lag screw fixation. They conduct part or all the forces from one fragment to the other. In metaphyseal areas, internal fixation requires protection with plates that support the underlying cortex. These are called buttress plates. If a fracture is reduced and a plate is applied to the bone in such a way that axial compression is generated, the plate is referred to as a compression plate. Plating on the tensile surface of eccentrically loaded bone increases the amount of axial compression when bone is loaded. Such a plate is referred to as a tension band plate. Perop photo of fixed fracture ulna. with reconstruction plate and interfragmentary screws In bridge plating, the fracture is first reduced by indirect reduction and the fracture is then bridged with a plate that is fixed to the proximal and distal main fragments maintaining length, rotation, and axial alignment but without aiming for anatomical reduction. Bridge plating is indicated only for the fixation of multi-fragmentary fractures. For simple transverse or oblique fracture, then absolute stability must be achieved by means of interfragmental compression. [Read more on plating in orthopedics] Intramedullary Nailing Illustration showing intramedullary nailing in the femur Intramedullary nailing can be compared to a tube within a tube. After fixation, the nail is in contact with cortical bone that allows a nail to control angulation and translation. Intramedullary nail is a load-sharing device and much stronger than a plate which allows early weight bearing. Locked intramedullary nail has allowed the nail to be used for a wider range of fractures than non-locked ones which could only be used in the middle third region of the diaphysis. With C-arm and locked intramedullary nail, fracture fixation can be proceeded without exposing the fracture site and disturbing fracture hematoma. Closed locked intramedullary nailing results in rapid healing, low complication rate, and excellent return of full function. Elastic nails are special thin nails used for fixation in bones of children and non-weight bearing bones of adults. Wires/Pins AP View Of United Supracondylar Fracture of Humerus With Kwires In situ Fracture Upper End Humerus Fixed With K-wires Distal Femoral Physael Slip – Reduced and Fixed With K-wires Kirschner wire or K wire has a great role in the management of orthopedic trauma and correction of deformities. Kirschner wire is also known as K pin. Kirschner wire is sharpened, smooth stainless steel pins available in different diameters and lengths. They are used both in the surgical and conservative management of fractures. In surgery, they are either used to hold the fracture fragments temporarily before the definitive implant is put or are used as for definitive treatment of fractures too. Most commonly, wires are utilized as provisional fixation before definitive fixation with a stronger device. Permanent fixation options include fractures in which loading is minimal or protected with other stabilization devices, such as external fixators, plates, and braces. Pin or wire fixation is often used for fractures of the phalanges, metacarpals, metatarsals, proximal humeri, and wrists. For bones like patella and olecranon tension band wiring is used and accomplished with a combination of K-wires and stainless steel wires. Fracture of Patella Treated with Screws and TBW Methods of Reduction in Internal fixation A direct reduction is the direct manipulation of bony fragments during an open reduction of a fracture after exposing the fracture site An indirect reduction is the reduction of a fracture by means of traction. It can be done by manual pulling or using distractor. Internal fixation of Articular Fractures Fracture Capitellum and Medial Epicondyle Humerus Fixed With Herbert and Cancellous Screws – Anteroposterior View Perop Photograph after fixation of the fracture of capitellum Intra-articular fractures and periarticular fracture treatment has been revolutionized by internal fixation. Articular reconstruction must be undertaken as early as possible and with the least trauma to the tissues. External fixation is frequently used as a temporary measure to achieve length and alignment of the metaphysis where a delay in definitive fixation [which could be 2-3 weeks also] is contemplated due to soft tissue injuries. The principles of articular fracture surgery are Anatomical reduction Stable fixation Correction of axial deformity Metaphyseal reconstruction with bone grafting of defects Buttressing of the metaphysis with buttress plates Early motion Implant Removal after Internal Fixation of Fractures The bone that unites fracture in the initial phase is of lesser strength. Furthermore, the bone that unites with primary healing is weaker than bone that unites with callus. The early bone over the time is remodeled to replace with stronger bone, a process that continues for a year or so. Factors which affect the remodeling phase are Patient's age Degree of comminution The degree of soft tissue injury Size of the bone gap The accuracy of the reduction Stability of the fixation Whether bone grafting was done or not When considering an implant removal, these factors must be thought into. Premature removal of implant would lead to a risk of refracture. It is generally agreed that most implants used for internal fixation should be left for about 2 years before their removal is contemplated. K wires and elastic nails are removed after a few weeks in hand and foot to facilitate motion. Elastic nails in growing children need to be removed earlier as they hardly contribute towards load and the removal becomes difficult after the bone has grown. Following removal of an implant, the bone must be protected from overload. The screw holes act as stress raisers and carry the risk of fracture especially in the first 6-8 weeks. Biodegradable Internal Fixation Biodegradable implants offer the theoretical advantage of eventual resorption, eliminating the need for later removal but current bioabsorbable implants do not have mechanical properties to match metallic implants and therefore, their indications are limited. These devices can be considered in low-stress areas is needed, pediatric patients,n medial malleolar fractures, syndesmotic fixation, or osteochondral fractures in adults where an early implant removal is almost always needed.

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