Evaluation of fracture fixation

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Abstract: Fractures heal naturally. To prevent malunions and nonunions fractures need to be treated. Earlier treatment for fractures was mostly immobilization with splints. Prolonged immobilization causes fracture disease. Fracture fixation principles have evolved from anatomical reduction, rigid fixation to functional reduction and stable fixation. Understanding and preserving the biology of the fracture has been recognised. Plates and screws have evolved from simple form to more advanced locking plates. Minimally invasive methods are now used to preserve biology of the fracture and reduce complications. Bone stimulants and stem cell have been found useful in resistant nonunions and infections.

Key words: Dynamic compression plates, Locking plates, Osteosynthesis, biological fixation, Functional reduction, relative stability, biomechanics

Fractures healing is a biological response and natural occurrence in all bones. However, due to the constant movement by the adjacent muscles, often they fail to heal or heal in unacceptable position. Throughout human history all cultures have devised treatments to heal the fractures in acceptable positions. Hippocrates suggested splints to stabilize the fractures after reducing them by various means. In ancient India and still practiced in many parts today, application of vegetable and animal extracts and splinting them with padded bamboos have been in practice. Massages with vegetable oils help increasing blood supply and help bone formation. European and Persian cultures have practiced a variety of methods to reduce fractures and maintain reductions.

Fractures might have healed but these prototype treatments have had complications mostly nonunions and malunions. Even if the fracture healed well, prolonged immobilization and non weight bearing results in stiffness, muscle atrophy, Skin atrophy and circulatory dysfunction. The disability resulted out of this so called “Fracture disease” is often more serious than the fracture itself (Perkins). To prevent fracture disease the limb must be mobilized early while the fracture is still healing. It is only possible if the fracture is fixed either by an external fixation or by an internal fixation.
Prior to 1950s attempts of fracture fixation were not very successful as the understanding of the biology and biomechanics of the fracture were limited and the implants available were of poor quality. It was in 1958 for the first time a group of European physicians (Muller, Schneider, Allgöwer and Bandi) formed an association called AO (Association for Osteosynthesis) and together developed sound and scientific principles of fracture fixation. The principles were framed and supported by extensive research and detailed documentation. They suggested that fracture fixation should include Anatomical reduction, Rigid fixation, Preservation of blood supply and Early active movements of the joints. In the following years Rüedi and Allgöwer documented and published 487 consecutive Tibial shaft fractures treated by plating with excellent functional outcomes of 98% union and only 3% sepsis.

Better understanding of biomechanics, design concerns and metallurgy have lead to the development of better implants. Plates with dynamic holes called Dynamic Compression Plates (DCP) allow self compression of the fracture during fixation. Compression and rigid fixation found to result in primary union of the fracture without callus formation. Various forms and designs of screws were also developed to address issues of soft bones, compression of fractures and to suit different anatomical locations. Specialised instruments were designed and training programmes were organized to standardize the fixation techniques. By this time intra medullary nails were already developed by Kunchnner to fix long bones were also in wide usage. The nails were considered bio mechanically more stable and load sharing devices and superior in fracture treatment of diaphyseal fractures of Tibia and Femur.

These principles were quickly adopted by many centres across the world and reported variable results.

Tibial shaft fractures treated by plating published in Glasgow reported 30% sepsis with 20% non-union and St. Thomas Hospital London published 20% sepsis with 20% non-union which were considered to be very poor results. This was due to the fact that much importance was given to anatomical reduction and rigid fixation with out much attention to the biology of fracture and its blood supply. By 1990-2000 the Association for Osteosynthesis (AO) have reframed the fracture fixation principles with more stress on Biology of the fracture. In diaphyseal fractures there is no need for anatomical reduction (only functional reduction) and some movement (relative stability) can be allowed encouraging callus formation. Whereas in the case of articular fractures anatomical reduction, rigid fixation and primary bone healing is mandatory. The important issue is to preserve the biology of the fracture. This could be achieved by Minimal access surgery, Preservation of blood supply, Functional reduction, Stable fixation and Early active mobilization.

Since application of Dynamic Compression Plates on to the surfaces of bones involve interference with the blood supply to the fractured ends, the plate designs needed improvisation. Avoiding total contact to the bone allows less interference of the blood supply. This concept lead to the development of "Low Contact Dynamic Compression Plates (LCDCP) and subsequently Pont Contact Dynamic Compression Plates" (PC FIX).

Opening the fracture to obtain reduction is likely to interfere with the blood supply to the fracture. Closed methods of reduction and fixation of the fractures is less likely to interfere with the blood supply. Even if there is need for opening the fracture it should be minimal with least insult to the soft tissue envelope. This "Minimally Invasive Osteosynthesis (MIO) technique allows least disturbance to the blood supply yet achieving fracture reduction and stabilization. In this Concept of biological fracture treatment the emphasis is on reducing the iatrogenic trauma (surgical footprint) caused by surgery. Preserve blood supply to fracture fragments and keep the proper environment for bone healing are given great importance. A variety of techniques and a host of specialized instruments are available for indirect and closed reduction of the fracture. Even if it needs to be opened as minimal as possible insult to the blood supply is to happen.
A more recent “Locking plates” is further advancement in biological fracture fixation treatment. Locking plates now are widely used and they address a whole range of fractures with a very high success rate. Unlike the conventional plate screw system, in the locked plate the screw head is firmly locked in the plate hole by the opposing threads. Thus both the plate and the screws act like one locked plate screw unit system. It functions like an internal fixator providing stability to the fracture and preventing loosening and screws backing up. It is particularly useful in osteoporotic situations where the pull out strength of the screw is low. Their ease of insertion and ability to be applied without opening the fracture is another great advantage. They are particularly suitable in minimal access surgery (MIPO) providing functional reduction and relative stability. More recently anatomical and site specific plates are also available providing solutions to many specific clinical scenario.

Intramedullary nails by virtue of their shapes and location being close to the centre of weight bearing are ideal implants for fracture fixation of long bones particularly Femur and Tibia. While Plates are placed eccentric to the load bearing axis of the long bones and therefore subject to higher stresses and risk failures, nails are inserted in the medullary canal close to the load sharing axis and considered as superior in load sharing. Kuntchner nails (K Nails) have been in use for a long time and were the main implants of choice for the treatment for most of the diaphyseal fractures of Tibia and the femur. Conventional K nail demands opening the fracture for insertion. It also can not provide rotational stability in diaphyseal- metaphyseal region as the medullary canal is wide at that places. This restricts the K nailing only to the fractures of the middle third of long bones. In the case of comminution and segmental fractures then fracture fixation by K nail is unstable even in the diaphysis zone. The K nail is unsuitable in these clinical situations. Advancement in the designs and the provision for locking bolts both proximally and distally has allowed extended indications for nails as fracture fixation devices. This has helped in usage of nails even in the fractures of metaphyseal regions and in multi fragmentary and grossly comminuted situations. Further design improvements allowed extended usage of nails making nails the choice of implants even in those metaphyseal fractures with articular surface involvement. Invention of image intensification has made live visualization possible and helps insertion of nails and locking bolts in long bones without opening the fractures making nailing a true minimally invasive surgery.

External fixation devices also have been improvised. Their ease and quick application make them to be very useful in life saving damage control surgery. They are also used as temporary skeletal fixation devices in open fractures and in fracture reduction techniques during internal fixation methods.

The current fracture fixation principals suggest in case of articular fractures anatomical reduction, rigid fixation and early mobilization are essential in order to develop smooth and congruent articular surface. This primary bone union without callus formation is essential for good joint function. Where as in case of diaphyseal fractures anatomical reduction and rigid fixation should be replaced by functional reduction and stable fixation. This allows callus formation which is essential for strength. As long as the length, axis and rotation are restored and fixed with relative stability the long bone fractures will heal well without any disability. It is not important how the fragments are aligned and it is not necessary to perfectly and anatomically align them. Preservation of biology of the fractured ends is paramount. Specialized techniques and instruments are now developed to achieve this objective of reducing the fracture functionally without opening and obtaining stable fixation. To obtain good results a proper preoperative planning is essential regarding the modes and tactics of reduction, the types of fixations, the types of implants needed. Fail to plan is plan to fail. A complex articular fracture with metaphyseal extension can be fixed well by biological fixation if the sequence and fixation tactics are well planned. First the fracture should be temporarily reduced using an external fixator. Articular fracture reduced by ligamentotaxis should then be fixed rigidly with interfragmentary compression screws percutaneously. The long metaphyseodiaphyseal fractures then should be fixed using a long locked plate threaded submuscular with minimally invasive techniques. This Minimally Invasive Plate Osteosynthesis (MIPO) is proved to be a very efficient way of fixing complex fractures.
without much disturbance to the blood supply of the fragments and thus preserves biology. The risk of non-union, requirement for bone grafting and incidence of infections are significantly less compared to the conventional open plate osteosynthesis.

With advancement in implants design it appears that there is little that needs to be done in the way of implant improvisation. Yet non-union of fractures still remain the substantial problem. Five to ten percent of fractures still do not unite. This is due to Soft tissue trauma, Impaired biology and insufficient understanding of biomechanics. Open fractures, segmental defects, dysvascular segments, chronic nonunions and Infection still remain considerable challenges in fracture treatment. Efforts to stimulate bone healing by utilizing osteogenic and osteoinductive potentials of certain bone substitutes are already been in clinical use with encouraging results. These are proved to be as good as auto graft without any morbidity and disadvantages associated with autograft. Bone Morphogenic proteins (BMP2 and BMP7) is known to have good osteogenic properties and proved its efficacy in multiple trials. Plasma Rich Protein (PRP) is another substance which has many advantages in certain clinical circumstances. Mesenchymal Stem Cells (MSC) have been proved to be effective alternatives in resistant nonunion and certain specific clinical circumstances.

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Biography

Currently working as senior Orthopaedic and joint replacement surgeon in Mediciti Hospital, Hyderabad. As the Chief Executive Officer for the attached post graduate Medical college (MIMS), responsible for the clinical and academic activities for undergraduate and post graduate medical students. Received primary and advanced Orthopaedic training in the United Kingdom and gained extensive experience in tertiary trauma care both in the UK and in India. Developed special interest in Joint Replacement surgery and Trauma Surgery and established tertiary trauma care centre. Associated with the AO teaching programme as a faculty, Chairman in basic and advanced teaching courses in India.

Participated in several national and international conferences as faculty and received awards. Wrote articles on the status of Emergency medical Service in India. Been as invited and guest faculty in many conferences. Particularly interested in the status of orthopaedic operation theatres and treatment protocols in India and an ardent supporter of improvising and standardizing trauma practices in India.