RESEARCH

Damage Control Orthopaedics; First and Final Use of External Fixators

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Abstract: This study was conducted in department of Orthopaedics Muzaffarnagar Medical College, Muzaffarnagar U.P. India from January 2017 to January 2021. The aim of this study was to evaluate the effectiveness of unilateral, Uniplanar, External fixation as a primary & definitive treatment for open fractures or fractures with severe soft tissue injuries & multi system trauma. A total of hundred patients were treated and studied. A Unilateral external fixation can be used as definitive treatment & a properly applied fixator allows bony & soft tissue stability quickly & with ease of application. The principles of successful application of monolateral external fixation, including the rationale for choosing this type of device, the assembly of its components & deciding plains of application are discussed. External fixation is primarily indicated in damage control Orthopaedics for multi system trauma management, situations in patient with concomitant destabilisation because of other injuries like severe soft tissue trauma, head injuries, chest injuries, abdominal injuries, excessive swelling. Poor skin condition, systemic instability, stabilization for transport, it's a handy tool. External fixation was done in 100 cases & were studied. It was found out that in 93% of cases union was achieved with very early mobilization & no second surgery was required hence it was used as definitive treatment.

INTRODUCTION

This relatively new concept aims at reducing mortality by advocating a temporary management of the fracture and soft tissue injuries in a multiple injured patient or a badly comminuted fracture with or without soft tissue injury, in a patient , till the patient is stable enough to tolerate a definitive procedure[1].

The concept advocates that a multiple injured patient or patient having severe injury in one bone, had sustained a "Hit" in the form of injury high energy impact during trauma. Subjecting him to second "Hit" in form of a major surgery (for definitive fracture management) when he is not too stable to bear with it may not be a rational option. Surgery itself is a kind of trauma and thus second hit in an already polytraumatised patient may worsen his condition. Hence, management in a multiple injured patient should be split up into emergent and definitive procedures.

The External Fixation (EXFIX) is one of the most important weapons of Damage Control Orthopaedics (DCO), in the armamentarium of an orthopaedics surgeon in case of polytrauma / badly fractured bones requiring lengthy procedures to fix them.

External fixation provides rapid temporary stabilization of fracture during early phase, reduces further tissue damage and help in patients mobilization. Once the patient's condition is optimize (5-7 days) definitive fixation can be undertaken[1].

"Damage control" is a term of naval origin used to describe the procedures performed to keep a damaged ship afloat while at sea. In medicine, this term was first used by general surgeons to describe immediate life saving procedures to control haemorrhage and minimize lengthy definitive procedures that may be deleterious to patients following such trauma. Only after the patient is adequately resuscitated and stabilized are definitive procedures performed[2].

The term DCO was first used by Scaleo ET all[3]. To describe a similar approach to musculoskeletal injuries. Temporising treatment methods such as EXFIX are used on unstable or borderline patients to stabilize major orthopaedic injuries, halt ongoing musculoskeletal injuries and control haemorrhage. These principles are very applicable to the injuries sustained on the battle front or in wake of disaster or common accidents. Additionally battle field or disaster orthopaedics must take into account of factors such as the number of patients needing treatment, available resources, fitness of patient for transport, weather conditions and availability of wound care[4].

The role of External Fixation in DCO has been well described. In civilian trauma settings, DCO refers predominantly to the expedient use of external fixation in acute management of pelvic bone or long bones fracture in multitraumatised patient or patient with some other difficulties. This provides early fracture stability while avoiding deterioration of the patients physiological condition as a result of

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either prolonged surgery or embolic phenomenon related to provisionally managed periarticular fractures while awaiting the recovery of the soft tissue envelop to the point where a formal surgical approach and internal fixation is safe with respect to wound complication risk[5].

This study conducted in Department of Orthopaedics , Muzaffarnagar Medical College, Muzaffarnagar aimed that if External Fixation is used as definitive fixation so that a secondary procedure can be avoided what is the outcome of treatment.

Since 1970 Intramedullary nailing (IMN) has yielded improved clinical and functional results in trauma surgery[6-9]. A surgeon tasked with treating severe open fracture of the femur or tibia or treating multisystem trauma involving femur or tibia or other long bones is confronted with the same question; would it be better to perform IMN or should the external fixation is done in a way so that it stabilize the bone, does not tax the patient further and no secondary procedure is needed.

The technique of EXFIX was popularised in the mid twentieth century when Hoffman introduced a device that used Steinman pins and bars to stabilize long bones fractures. Charnley concomitantly impressed the orthopaedic community when he introduced an External Fixation for knee arthrodesis. With a simple compression frame, he was able to dramatically increase knee fusion rates and decrease consolidation time[10]. Behrens described basic concepts that govern the safe and effective application of external fixation frames for bony trauma[11].

The pins and wires should avoid the damage to vital structures.

Allow access to the area of injuries.

Meet the mechanical demand of the patient and the injuries.

In the early and mid 20th century good outcomes relative to other forms of treatment were reported with external fixation devices used in long bone fractures[12,13]. However non-union, mal-union, and pin tract infections complicate external fixation treatment.

In 1960s acute stabilization of long bone injuries in multisystem trauma patient was associated with an unacceptably high mortality rate[14]. Acute respiratory compromise and pulmonary failure were attributed to fat embolism from intramedullary instrumentation and suboptimal mechanical ventilation protocol mortality rate approached 50%[15].

While the western world was using EXFIX sparingly, it was becoming the main stay of Orthopaedic treatment in Asian countries. In Kurgan, Siberia Professor Ilizarove found external frames to be invaluable for a myriad of applications including post traumatic and congenital limb reconstruction, limb salvage, complex arthodesis, management of osteomyelitis and bone defects and deformity correction , using a circular fixation design with simple and versatile components, he was able to develop a method for osteogenesis that relied on a percutaneous approach with minimal trauma to the limb, closed anatomical fracture reduction and excellent bone stability that allowed early weight bearing[16].

Three basic types of external fixation frames used in practice today constitute either circular, unilateral or hybrid frames[11]. when considering unilateral frames, two most common design are the bulkier mono body design (Orthofix, Verona, Italy. EBI Parsippany USA.) and fixation used in trauma, pin to bar Universal fixator.

The mono-axial and mono-lateral frame were successfully used for the treatment of open and infected fractures, segmental fractures, leg lengthen and segmental bone defects.

In the austere environment typically associated with combat injuries, natural disaster and mass casualties, "damage control' and the role of acute external fixation are expanded beyond this. In addition to limiting damage to the extremity and the overall well being of the patient, it represents the primary and some time only mode of instrumented fracture fixation available to surgeon. ExFix is a rapid means of providing relative fracture stability in preparation for the transport of patient to higher level of care for continued management and in temporizing treatment to a large number of patients quickly in the setting of mass casualty events or in a patient where there is need for fixation and fast. As such there is a high incidence of open wounds, necessitating serial wound evaluation and debridement or frequent dressing change as a part of wound management. This is a significant easier for both the, patient and the provider, to manage with patient in an external fixation than immobilized in splint[17].

The specific techniques employed for Damage control Orthopaedics external fixation varies greatly as a function of patient volume, associated injuries, open injuries and available equipment. However, the general principles remain the same for multisystem trauma patient.

First and foremost standard external fixation applies. Optimizing fracture reduction, cortical contact and increasing pin diameter will increase the stability of the construct. Additionally, increasing the number of connecting rods, decreasing their distance from bone, increasing the number of pins and optimizing their spread and location relative to the fracture site also improve stability[18]. These factors, however, must be prioritized against competing interests, particularly with respect to patient's general condition, other multisystem trauma, and zone of soft tissue injuries.

Fig 1. External fixation in fracture Intertrochentric femur

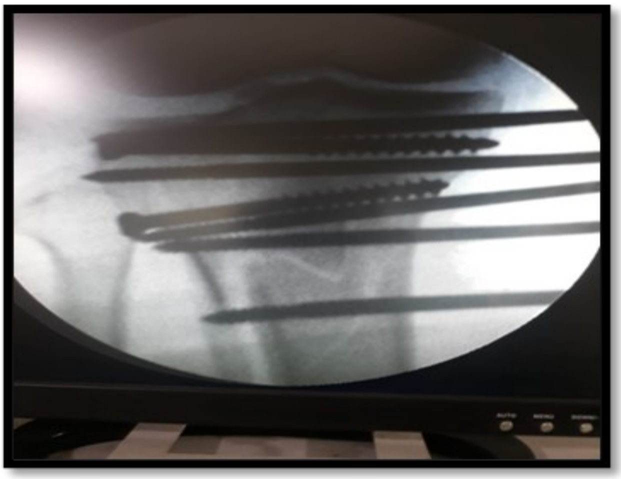


Fig 2. External fixation in proximal tibia.

AIMS

The study was conducted in Department of Orthopaedic, Muzaffarnagar Medical College, Muzaffarnagar Uttar Pradesh India, from January 2016 to January 2021. In this study 100 cases were studied. Aim of the study were –

1. Role of External Fixation in Damage control Orthopaedics, Early total care, on long bones fractures in combination with multisystem trauma, soft tissue damage, comminuted fractures or all of them.
2. Can external fixation be used as first and final surgery?

3. Are the role comparable to other methods of treatment like closed nailing or various type of plating.
4. What are the complications if external fixation was used and how was the course of illness.

Object used was External Fixator, unilateral and uni-planer. In our series;

1. 31 fractures were Gustilo type 1 & 2.
2. 19 fractures were chest injuries, and head injuries.
3. 12 fractures were with abdominal injuries.
4. 11 fractures were Gustilo type 3 with nerve injuries.
5. 8 fractures were with Embolism.
6. 6 fractures were with head injuries requiring surgery.
7. 6 fractures were with clinical signs of compartment syndrome.
8. 4 fractures were with Deep Vein Thrombosis.
9. 3 fractures were with Hepatitis C or HIV.

Thus 100 cases were studied.

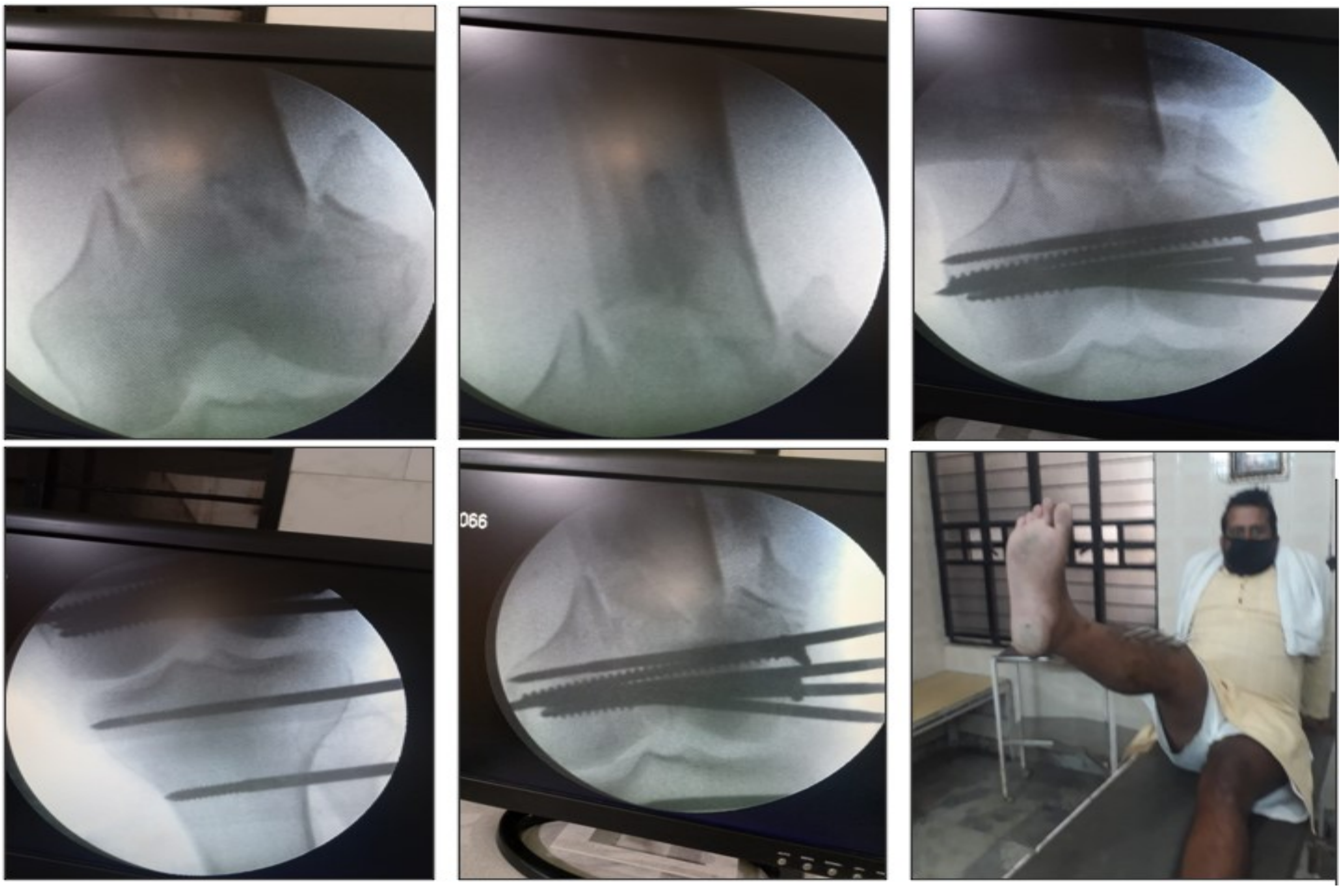
The indications for the use of Damage Control techniques with uni -axial uni-planer fixation includes stabilization of open fractures along with other procedures taking primacy in saving life of patient. External fixation was considered;

1. In unstable patients with multiple other injuries and other concomitant lower extremity osseous trauma.
2. The initial management when definitive treatment should be delayed to optimize the risk benefit of additional definitive care, in our study we tried to put initial fixation with external fixator in such a way that secondary procedures to treat bone fracture is not required.
3. In high energy Tibial plateau, distal Femur or distal Tibial fractures in which there are wound that prevents soft tissue coverage or the skin is unsuitable for definitive reduction and internal fixation.
4. In austere or hostile environment in order to facilitate care or transfer.

We followed these patients for a minimum duration of 10 months and some till this date and analyzed the results.

RESULTS

1. The mean age of patients at the time of injuries was 38.6 years (range from 15 years to 77.8 years).
2. There were 70 males and 30 females.
3. 62 patients were injured in motor vehicle crash and 38 patients had trauma due to fall from height. Mean time from the accident to surgery was 10 Hours.
4. If patient had union within 6 months than it was considered normal healing, between 6-8 months delayed union and non union if there was absence of union after 8 months. Radiological assessment was done to asses union.
5. Mean time to fracture union for 82 open or compound fractures that did not require a change in fixation or bone grafting was 23 weeks Range from 17 weeks to 24 weeks, 11 fractures requires average 30 weeks to unite but 7 fractures did not unite.
6. These 7 cases required nailing bone grafting in 4 cases and in3 pins had to be removed as they have become loose and then plating with bone grafting was done and yielded union in all 7 cases within 4 months of second procedure.
7. In 93% cases union was achieved on external fixation without need to change it or go for second procedure so we can safely say that external fixation can be used as first and definitive fixation.
8. The patient were encouraged early movement of knee and ankle joints and muscle exercise in lower limb injuries and same way movement of hands and elbow. Axial loading and dynamization was individualized. Early dynamisation was done only in transverse or short oblique fractures. Generally, patient's weight bearing was allowed as early as possible in some cases even within 7 days and in all cases full weight bearing with support in hand with in 6 weeks was encouraged. Each patient was evaluated clinically and radio logically at every month postoperatively till union is achieved. Fracture healing was assessed by standard radiographic projections and union defined as dense callous bridging at least 3 cortices.



Case 1: Severely comminuted lower end femur with abdominal injury external fixation was done with knee spanning fixator, patient was mobilized on 21st day & union was achieved in 25th week.

9. After radiographic confirmation and assessing walking comfort clinically gradually pins were removed from either side of fracture and ultimately as whole of the fixation device was removed the patient was walking normally.
10. Pin tract infection and deep infection – pin tract infection is an inherent problem in external fixation. There were 38 patients of pin tract infection in our series. There were 3 cases of osteomyelitis in all open fractures. All fractures of pin tract infection and osteomyelitis were managed with IV antibiotic, cleaning and debridement. In one case pin has to be removed and reinserted from different direction.
11. There was no restriction of motion to knee or ankle of hand or elbow joint. No patient complained of pain on his latest follow-up.
12. In 8 patients of fat embolism was diagnosed while pulmonary embolism was a complication in 5 of them. Rest had various features cerebral and cutaneous and resolved.
13. Deep Vein Thrombosis (DVT) based on clinical examination was suspected in 9 patients but was confirmed only in 4 patients with ultrasound and resolved with treatment.
14. Associated injuries distribution is shown in table 2. It was found out that-
   a. Maximum number of bone which had difficulty to unite were in 2nd group of 19 fractures which have head, chest and abdominal injuries association followed by Gustilo type 3 injuries group of 11 fractures . Not only they took longer duration to unite they also have maximum number of cases (5&2 respectively) where revision surgery was required along with bone grafting. It was also observed that though early stabilization helped stabilizing patient systematically, reduced complications but multi system injuries put a toll on body and debilitation it caused lead to failure of union. All cases united after revision surgery and bone grafting.
   b. Fractures in association of head injury (whether requiring surgery or not) united in normal time.
   c. HIV and HCV patient fractures were fixed with External Fixation united in the end of normal time, towards 24th week. All three were diagnosed with investigations while preparing for surgery and were not aware of disease beforehand.
   d. External Fixation proved to be as efficacious in treating these patients and was able to produce good results in 93% of cases.

Table 1. Union Time

Serial Number	Number of Cases	Time of Treatment Mean (In Weeks)	Time of Treatment Median (In Weeks)
1.	82 Cases	23 Weeks	24 Weeks
2.	11 Cases	30 Weeks	32 Weeks
3.	7 Cases	No Union Till 32 Weeks	Device Changed with Bone Grafting and within 24 Weeks All United.

Table 2: Fractures, Associated injuries, Procedures Results n=100

Serial number	Fracture	Associated injuries	Procedure done	Results
1.	31 fractures	Gustilo type 1 &2	External Fixation	Good 100%
2.	19 fractures	With head, chest injuries	External Fixation	14 fair 75.69% 5 required revision 26.31% N=19
3.	11 fractures	Gustilo type 3 injuries	External Fixation	9 fair 81.82% 2 required revision surgery 18.18%
4.	12 fractures	Abdominal injuries requiring surgery	External Fixation	Good100% require longer duration
5.	8 fractures	Embolism, pulmonary and other	External Fixation	Good 100%
6.	6fractures	Head injuries requiring surgery	External Fixation	Good 100%
7.	6 fractures	Compartment syndrome	External Fixation with facieotomy	Good 100%
8.	4 fractures	DVT	External Fixation	Good 100%
9.	3 fractures	HIV/ Hepatitis C	External Fixation.	Good 100%

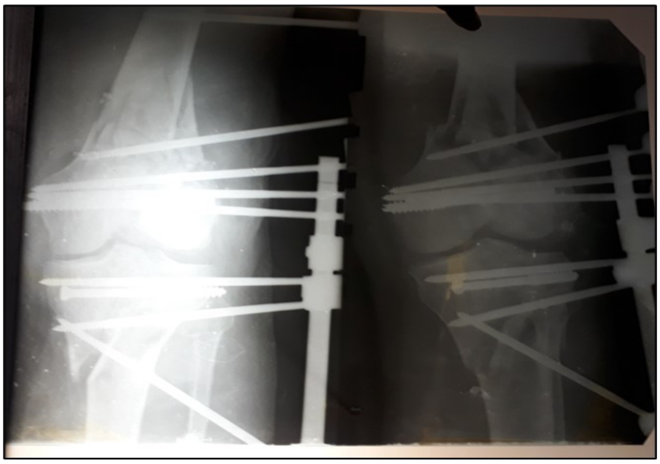


Fig 3: Case of spanning external fixation with periarticular injury along with head injury requiring drainage of extradural haematoma.

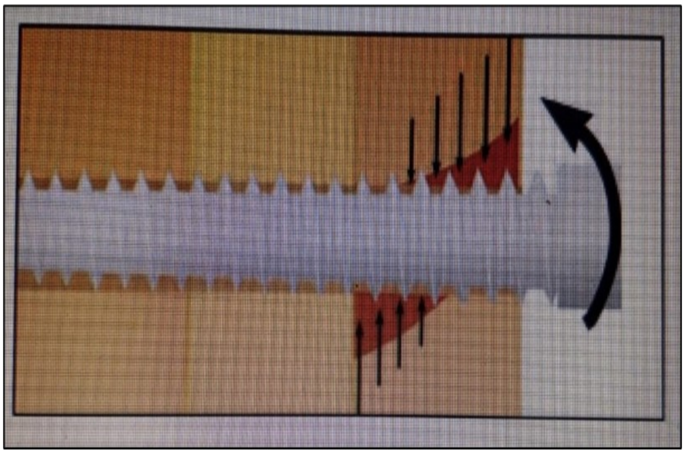


Fig 4: Radial stersses on loading

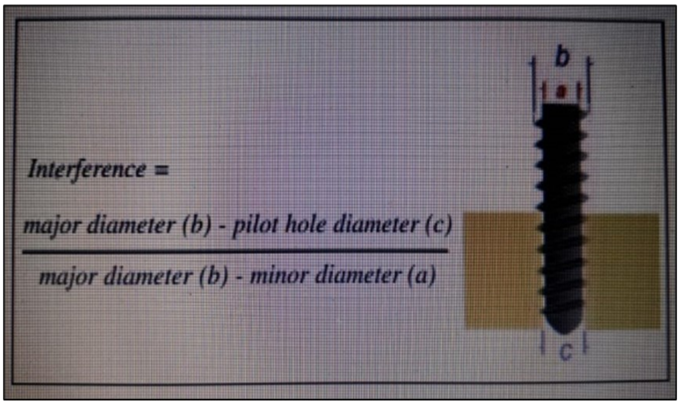


Fig 5: Interference

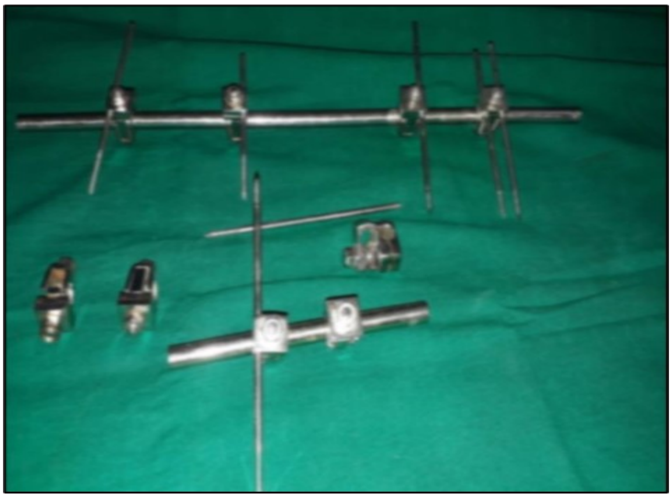


Fig 6: External Fixation Device, showing fixator assembly, bar + clamp + SCHENZ pins, Clamp, Open clamp Bar Connector.

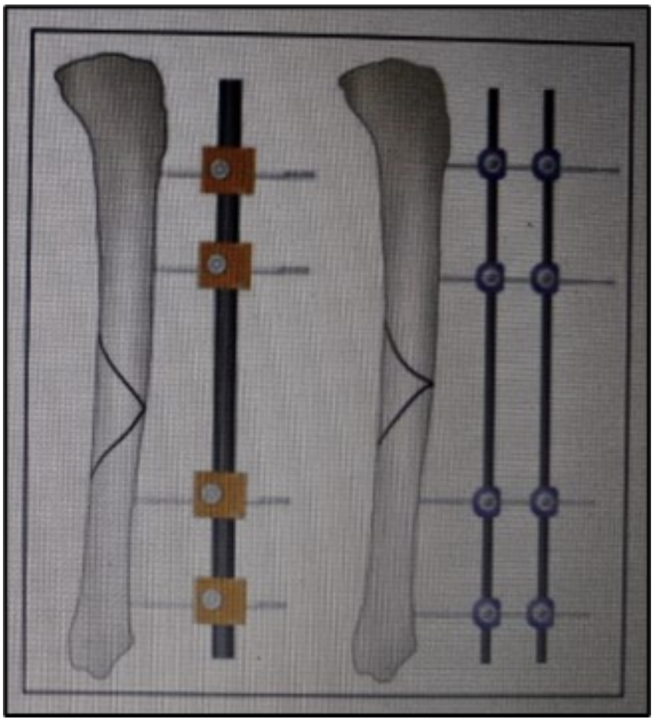


Fig 7: Double bar for additional

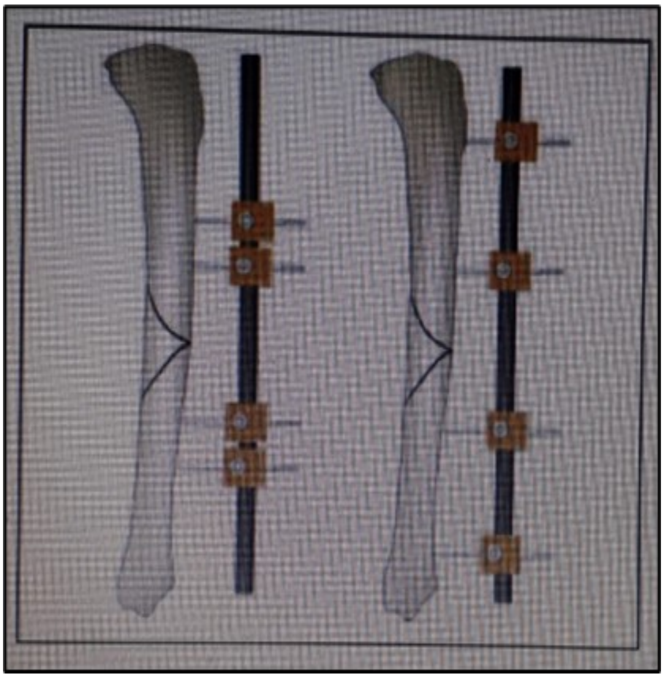


Fig 8: Spanning of external fixation

Case 2: Showing fracture lateral condyl tibia with dislocation knee, impenidng, compartmental syndrom with fracture clavicle & unstable chest injury united in 24 weeks.

DISCUSSION

The original description of the management of long bone fractures with external fixation is attributed to Keetley in 1893[19]. In an effort to decrease non-union and mal-union, rigid pins were inserted percutaneously into femur and attached to an external splint system. This concept was refined by Lambotte 1912 who added threaded pins and clamp to facilitate pin-bar interface[20]. Roaul Hoffman, Roger Anderson and others refined these techniques, developed closed reduction methods, minimum invasive protocols and stable constructs. Current external fixation system still utilizes these primary components.

The different external systems in clinical use today can be categorised into unilateral or circular types. Transfixing pins are sometimes still used in calcaneum if required.

Three variables which directly influence the contribution to stability in external fixation are

1. The bone pins interface.
2. The components of fixator.
3. The fixator configuration (how it is assembled on the inserted bone pins).

Bone Pin Interface;

This is the crux of stability, starting with hold and keeping a good hold of bone. Two important parameter that influence interface stresses and bone hold are pin diameter and interference;

a. **Pin diameter:** larger diameter pins have a higher resistance to bending forces (the cross sectional movement of inertia of any rod or bar structure increases with the 4th power of its radius), thus in turn can reduce the stresses at bone pin interface[21]. The limit to increasing pin size is set by the diameter of bone in which the pin is inserted – a hole exceeding 20% of the diameter of bone will reduce the torsion strength of bone by 34% and if the hole size is greater than 50% the reduction in strength is 62%[22,23]. In practice it is advisable to keep pin size with in a third of the diameter of the diameter of bone to reduce the risk of fracture on removal of Schanz pins. Hence a general guide line for the pin diameter has evolved and is to use 4.5 mm and 6.0 mm Schanz pins in Tibia/Femur or diaphysis/metaphysis.

b. **Interference:** Interference is a measure of the grip pin has of bone. Traditionally it is at its maximum at the time of insertion and may gradually decrease as the fixator is loaded. Therefore maximising interference at the beginning serves to promote the bone hold for longer duration of time[24,25]. However this cannot be achieved by simply reducing the size of the pilot hole. As such manufacturer – led recommendation on drill bit size prior to insertion are important if appropriate radial preload is desired. It should be noted that bending pins to create preload is less effective and should not be encouraged. Radial preload is more suitable way of increasing interference[26]. Manufacturer also have sought to maintain the grip on bone by altering material properties or surface coating of the pins. One technology that has shown promise in comparative studies and proven itself in clinical use is Hydroxyappatite coating of threaded pins – is one method by which hold increases with time[27-30].

c. Osteoporotic bone can nullify the effect of advanced screw thread design or metal-alloy composition in modern pins. This is because the cantilever loads on the pin at the bone-pin interface (especially when the patient is instructed to bear weight in the post-operative period) Can produced stresses that exceeds the yield strength of cortical bone and leave to resorption & loosening- all this even in the absence of pins sit sepsis. Historically, this explains why many users of external fixators did not allow their patients to walk on their affected limbs but in doing so deprived the fracture sit of an important form of stimulation of bone union hence the pre judicial view of external fixation leading to non-unions[31,32].

In our study we used self-drilling self-tapping 4.5/6 mm SCHANZ pin.

The components of the fixator:

Most unilateral system exist as one of two types; a construct e.i. pre-assembled or coms ready assembled before applications (and often incorporates design features that facilitated fracture reduction and dynamization), and one e.i. assembled from components after pin insertion. The later type has gain popularity for it provides the surgeon freedom of choosing pin location and configuring the fixator assembly according to the clinical problem. But the verity of using “snap on” components and “free style” assembly has this advantage that the in experienced users who is enamoured by this freedom risks applying the fixator that can be inherently unstable

Fixator components are

1. Pin clamp which are pinto bar connectors
2. Pins
3. Bars
4. Bar lamp which are bar to bar connector

Pin and bar clamp have joints that enable a universal joint action. Most main stream manufacturer have engendered these devices to provide ease of application without sacrifice of secure fixation when clamps is tightened. However it is the responsibility of surgeon to ensure the clamps are tightened very securely when the fixator has been applied as loose clamps are responsible for loose of fracture control. In particular those clamps that enable multiple pin attachment and are secured by more than one tightening bolt or screw, have tightened by alternating the twist between the bolts. This allows the clamp corner to close over pins equally and maintained a firm hold. If one bolt is tightened very firmly and the other less so, the clamp cover will rest tilted over the pins and gradually loose.

Connecting bars are available in different diameters and of various materials whilst stainless steel was previously popular, bars are now commonly made of aluminium alloy or carbon fibre composite. These provide strength (solid bars instead of hollow tube) with the benefit of reduced weight. Even so diameter of bar used is important. As previously stiffness increases with fourth power of the radius, and as manufactures provide bars from 8-14mm diameter, the surgeon has to recognise the limitations imposed when using smaller diameter bars. In such cases double staking the bars may compensate for the more flexible thinner bars[33].

Fixator Configuration:

This has a large contribution to the shared stability concept in the and exo and endoskeleton analogy. The manner by which the fixator is assembled can change this contribution though:

1. The number and spread of pins along the segment
2. The distance between the connecting bar & bone.

Pin number & spread:

An increase in stiffness is provided by increasing pin number from 2-3 in any one segment (segment being any substantial part created by fracture, therefore a simple transfers fractures has two segments). The aided benefit from increasing the numbers of pins from 3-4 is minimum, therefore at least three pins per segment is advice[34].

As for the pin spread the “near & far” rules provide a guide, pins should be spread along a segment of bone such that the segment is spanned[35,36]. The proximity of any pin to the fracture sit itself is cautioned as the pin may be within fracture hematoma & their by carry the risk of a pin sit infection spreading to within fracture. A rule of thumb staying at least 2cm from the nearest fracture line helps. Such application in practical terms should also take into account soft tissue damage & consideration for future plastic surgery, which sometimes limits the option of pin placement.

Connecting Bar Distance;

The distance of the connecting bar from bone is determined by the depth of soft tissue in between. Close proximity is possible on the antro-medial surface of the Tibia but reverse is true for the lateral surface of Femur. Bringing the connecting bar closer to bone improve the stability and in general it should be kept as close as possible with enough room to facilitate pin site care – at least 4-5 cm from the bone surface if feasible.

Pin number, pin spread and connecting bar distance can be varied to improve stability. The improved stability reduces the bone pin interface stresses and help preserve longevity of stable fixation[21].

Recognising the contribution of the endoskeleton to stability:

It is wrongly assumed the endoskeleton contributes little to over all stability- this is only true when little contact exists between fractured fragments such as highly comminuted patterns, bone defects or when fixation is used in bone transport or bone lengthening (where the bone ends are purposely separated). In other circumstances there is a shared stability scenario and the amount contributed depends on fragment contact and fracture pattern. A poorly reduced or comminuted fracture has little contact between fragments and as such weight bearing forces are almost entirely placed through the External Fixator, this creates high pin-bone interface stresses. Oblique pattern will also have the same effect to a lesser degree, but to a contrast, a reduced transverse fracture will share a significant portion of load transfer in weight bearing[24].

Optimizing the plane of external fixator application:

Fixator Schanz pins should be inserted in safe corridors and the most convenient is the antro-medial surface of Tibia, Lateral surface for Femur, saving radial nerve in Humerus . Attention to the plane of fixator application may yield additional stability as external fixation is to be used as definitive fracture treatment. We need to deduce the plane and direction of the injurious force from the fracture pattern.

Fracture patterns tell of the type of force that produced the fracture. Similarly these forces also produce soft tissue injury patterns. Both the fracture and soft tissue injury pattern influence the ability to maintain reduction, there is a tendency for the loss of alignment in the same direction as the original displacement. That being so, it is possible to apply uni-lateral fixator with due consideration to the likely displacing forces on the fracture:

1. Transverse fractures are created by tensile forces. If well reduced , these will only demand control of bending and torsion movements by external fixator as any further shortening is prevented by virtue of a good reduction and transverse fracture pattern. It has been shown that the major bending forces in the intact Tibia during walking occur in saggital plane[34,35]. When this information is coupled to the knowledge that any uni-lateral external fixator has the best control of bending movement in the same plane as that of pin insertion and is weakest in the plane right angle to this plane- the orthogonal plane[36]. So, an optimum position for a uni-lateral external fixator for this type of fracture is in saggital plane.

Bending forces create fractures with a butterfly fragment. The apex of the butterfly piece denotes the side of tensile forces and the broad part (base) of the fragment compression force. The plane and direction in which the bending force was applied at the time of fracture can therefore be deduced from plain radiograph. Any displacement after reduction will tend to mimic the position before reduction – this is a reflection of the fracture pattern and soft tissue disruption created by the original force. Control of this displacement can best be achieved by placing the fixator in the plane in which bending force was originally applied there by aligning the plane of control with plane of displacement. This deviation from the plane of fixator application is simple to work out from the position of butterfly fragment. There are instances when the most appropriate plane is not possible because of the constraints of safe corridor of pin insertion. In such scenario it is wisest to opt for a biplanar unilateral configuration.

Movement across the fracture site induces callous formation and promotes healing. External fixation is the only mode of treatment where cyclic movement can be controlled with dynamization. Kleen et all. Said that mechanical and histomorphometeric observations noticed significant inferior bone healing in IM Nailing group compared to external group[34].

External fixation can be done very quickly , they provide fracture stability and alignment with minimum physiological insult, there is no metal implant across the fracture site and there is less vascular damage to bone that may already be compromised. Another advantage of external fixation is that a second surgery is not needed with implications of cost effectiveness and patient's morbidity.

CONCLUSION

The general principles of external fixation apply to any situation or surgical environment and it remains the mainstay of the initial care for extremity fractures with some other difficulties like associated injuries. The world Damage Control applies for this early management which is not an attempt to delay treatment and not to induce further damage to the patient and limb. Rather it should instead be thought of as a calculated and systematic initiation of the process of limb reconstruction. Approaching external fixation placement through this shifted paradigm one can ensure both that initial patient management is optimised and subsequent treatment options are not compromised. Furthermore when external fixation becomes by occasion necessity, the definitive or only treatment the patient will receive for their fractures, this possibility was considered prior to initial placement of the device and external can be readily adapted to that role.

The Israeli forces utilized external fixation for battle casualties during the 1973 and 1982 wars for definitive care in 78 limbs with good results[37].

External fixators are versatile tools. They have advantage of per-cutaneous application and modifiable biomechanical characteristics. This study provides a biomechanical rationale for choosing fixator, its components, deciding optimum plane of application and configuring fixation in accordance to the injury pattern. It can also be used as definitive means of fracture fixation in multisystem trauma and where patients condition is not such so as to tolerate major surgery but do require stabilization of bony injuries. Results are comparable to any other means of fracture fixation and cost of second surgery is saved. It is easy to apply; its complications are very little and are easily managed.

When device is used for definitive fixation attention to detail in choice of pin diameter, plane of application and fixator configuration can make difference to a patient who can rehabilitate comfortable and stimulate fracture healing through weight bearing.

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