Open Fractures Caused By High Velocity. Missiles: The Outcome of Treatment of 39 Fractures Followed for 1-3 years

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Abstract

Between 1993 and 1995, thirty-three patients having 39 fractures caused by missiles fired from a high velocity rifle were reviewed retrospectively between 1 and 3 years after injury and the outcome of treatment assessed. Majority (33 out of 39) were Grade III. Union was achieved in 35 out of 39 fractures, there was deep infection and delayed union in one case each. Non-union occurred in three fractures. The fractures were stabilized using different techniques, but highest complication rate was seen with the use of the static external fixator. This was related to the severe nature of the injury as well as the inherent limitations of the external fixator. Revision of the external fixator with internal fixation after healing of the soft tissues seems to be the direction of the future (JPMA 47:274, 1997).

Introduction

Open fractures caused by bullets have been a difficult problem since the invention of firearms. Bullet or missile injuries are divided into low velocity and high velocity. High velocity missiles injuries are caused by bullets fired from weapons with muzzle velocity exceeding 300 m/sec.[1]. The fracture caused by such a missile is due to the high energy transfer which occurs at a ‘small area of impact causing shattering of bone and cavitation of the soft tissues[2]. The amount of energy dissipated at the moment of impact can be determined by the equation Em v2/2, where E is the kinetic energy, mis the mass andv2 represents the square of the speed. It has been estimated that total energy transfer exceeds 2000 foot-pounds of energy[3]. Most of these fractures belong to the severest grade[4] andthe literature quotes iniectionratesupto 50 percent for grade III B open fractures and amputation rates of 50 percent or higher for grade Ill C open fracture[5]. The magnitude of the problem of open fracture caused by high velocity missiles canbejudged from the factthat the Centerfor Disease Control at Atlanta has rated firearm injury related deaths as the leading cause of death in the young in USA[6]. In Pakistan, urban violence is a serious problem. In Karachi, there were over 2000 deaths in 1995[7]. The major difference with the Western world is that commonly used weapons in our setting are high velocity automatic weapons like A.K. 47 assault rifle. This has amuzzlevelocity of2300 feetpersecond and a rate of fire of 600 rounds per minute[8]. The objective of this study was to retrospectively audit the outcome of treatment provided and to identify variables to improve outcome.

Patients and Methods

This study is a retrospective review of all adult patients admitted to The Aga Khan University Hospital with open fractures caused by high velocity missiles during the period January, 1993 to August, 1995. It includes all those patients who have been followed for atleast one year (maximum of 3 years) after the injury and in whom all follow-up records were complete. Three patients were lost to follow-up after they had developed a complication. They were included in the results because their treatment had anived at a definite point and the complication was noted. During the study period, 33 patients fulfilled the inclusion criteria. Four of these patients had multiple open fracture giving us a total of 39 fractures in 33 patients. Fractures were graded according to Gustillo's classification[4]. This grading was based on the per-operative assessment of the wound. Two fractures were grade I open, 4 were grade II and 33 were grade III. Ahighproportionofgrade III fractures reflects the serious nature of the bony as well as the soft tissue injury. Grade Ill fractures were further sub-classified and there were 29 type Afractures, 7 were grade HI B and 3 were grade HI C'°. The patients had sustained multiple bullet wounds, having injuries to other body areas, which required additional surgical treatment. Seven patients had nerve injuries which eventually required repair and 5 had majorvessel injury, thoughonly 3 had grade III C fractures and vascular repair was required for limb survival. Majority of our patients presented within 6 hours of injury. However, 6 patients presented after more than 24 hours of injury. One patient presented 7 days after injury with open fractures of the humerus, radius and ulna and tibia. At presentation the tibial fracture was infected.

For a patient with an open fracture, management was initiated in the emergency room with attention to airway breathing and circulation and primary and secondary surveys to document the extent of the injuries to the body as a whole. The limb trauma was evaluated regarding the viability of the limb, the neurological status, the site and size of the entry and exit wounds. No wounds were explored in the emergency room, The limbs were splinted and X-rays were ordered. A preliminary grade was assigned to the fracture as the admitting diagnosis, pending final evaluation at surgery. Broad spectrum antibiotics were started in the emergency room after taking cultures. Tetanus prophylaxis was also given. The patient was taken to the operating room as soon as possible. In surgery, the extent of the soft tissue and bony injury was adequately staged. This was only possible alter extending the wound and often this resulted in a regrading of the fracture. A thorough debridement and wound irrigation with 8-10 litres of saline was performed and all devitalised tissue and avascular bone was removed. Fasciotomies were performed as needed. According to Gustillo's recommendation[4], internal fixation and wound closure was avoided at this stage. However, wounds extended during the debridement were approximated loosely. Ten fractures were stabilized at the stage of primary debridement as conditions were thought to be suitable. Six fractures (three upper limb and one proximal tibial fracture) were plated. One femoral fracture was fixed witha locking nail and one femomi head fracture with cancellous screws and revascularised with myo osseous graft. Two fractures were fixed externally. Four wounds were closed primarily and only one of these was a Grade III fracture.

The patients whose fractures were not fixed at admission or whose wounds were open returned to the operating room after 48 hours. At this time stabilisation of the fracture and wound closure was done only if the wound was healthy and cultures were negative. Organisms were cultured in six fractures. Antibiotics were then changed according to the sensitivity and wounds debnded until cultures were negative and only then was fracture stabilization and wound closure done. Antibiotics were continued for 3-5 days alter wound closure. Twenty seven fractures were later fixed and 4 were such that only plaster casts were needed. Of the fractures which were fixed, 7 femoral fractures and two humerni fractures were fixed with locking nails. Twelve fractures were plated and 4 were stabilised with external fixators. Five fractures were bone grafted primarily and 4 fractures (all tibial) required local muscle rotation flaps and skin grafting. Only 3 patients were manageable with skin grafting alone. Ambulation status was dependent upon the overall status of the patient. Weight bearing on the operated limb was allowed with crutches or walker depending on the stability of fixation of each fracture in the lower limbs. For the upper limbs slings or splints were used until range of motion was started. Patients over 40 years with lower limb injuries were anticoagulated using either Warfarin or Low Molecular weight Heparin (Fragmin) unless contraindicated.

Results

Of the 33 patients, 31 were male and 2 female. The age range was from 13 years to 70 years, with the peak incidence in the third decade of life. The patients included in the results are those who have been followed for a time between one to three and a half years (Figure 1-A, B, C).

Figure 1-A. A 70 year old male sustained a Grade III B open fracture of the right humerus.

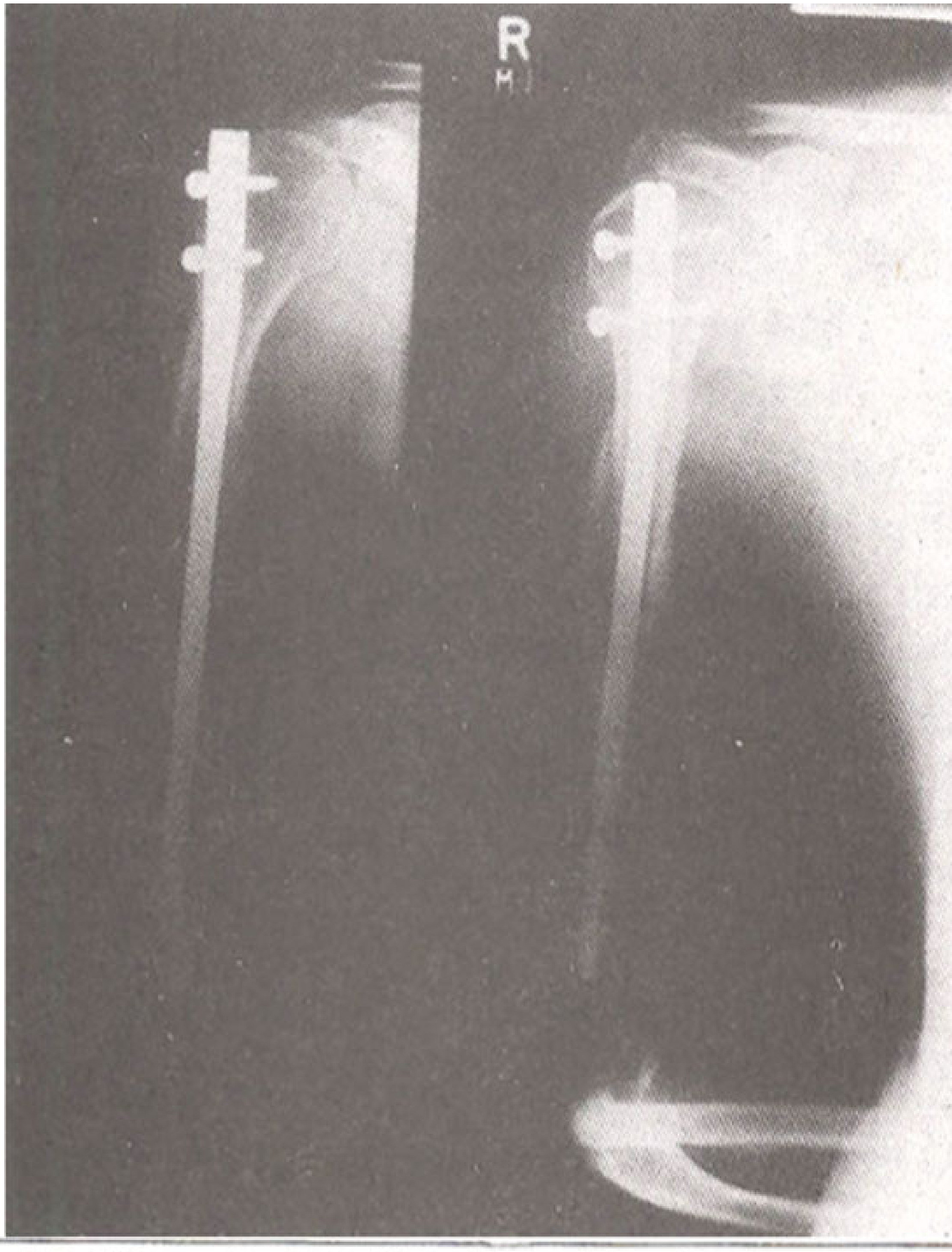

Figure 1-B. This was treated with locking nailing after three debridements.

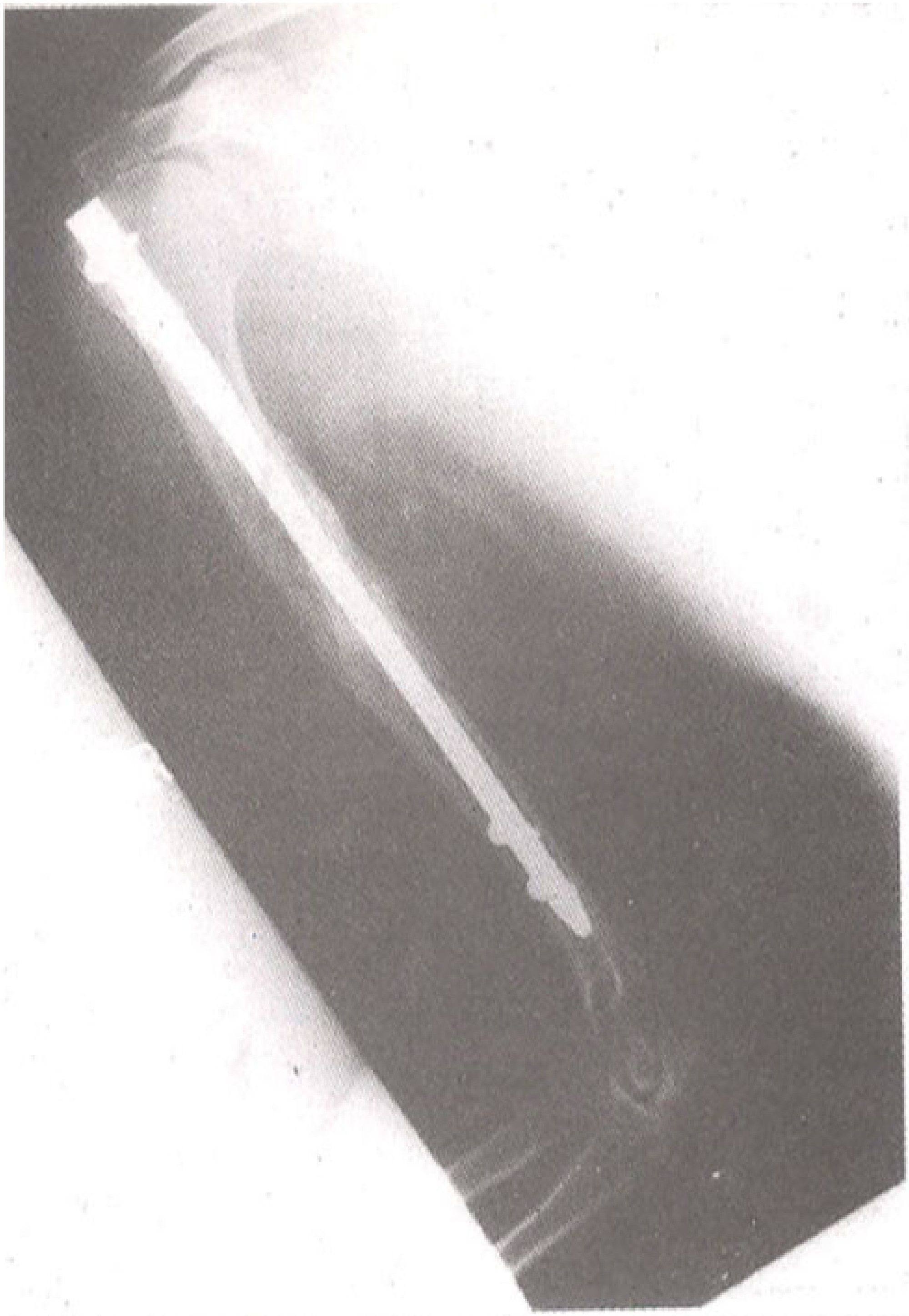

Figure 1-C. X-ray at three years showing consolidated fracture. The patient has a full range of motion at the shoulder (i and ii).

This is thought to be adequate because most complications are apparent within this period. Infections are usually seen in the first month4. The results of six Grade I and Grade II fractures are known. All healed in an average time of 8 weeks. Thus their outcome should be considered excellent. Of the 33 Grade III fractures, 29 united (Figure 2-A, B).

Figure 2-A. A 28 year old male sustained a Grade III B open fracture of the right proximal femur.

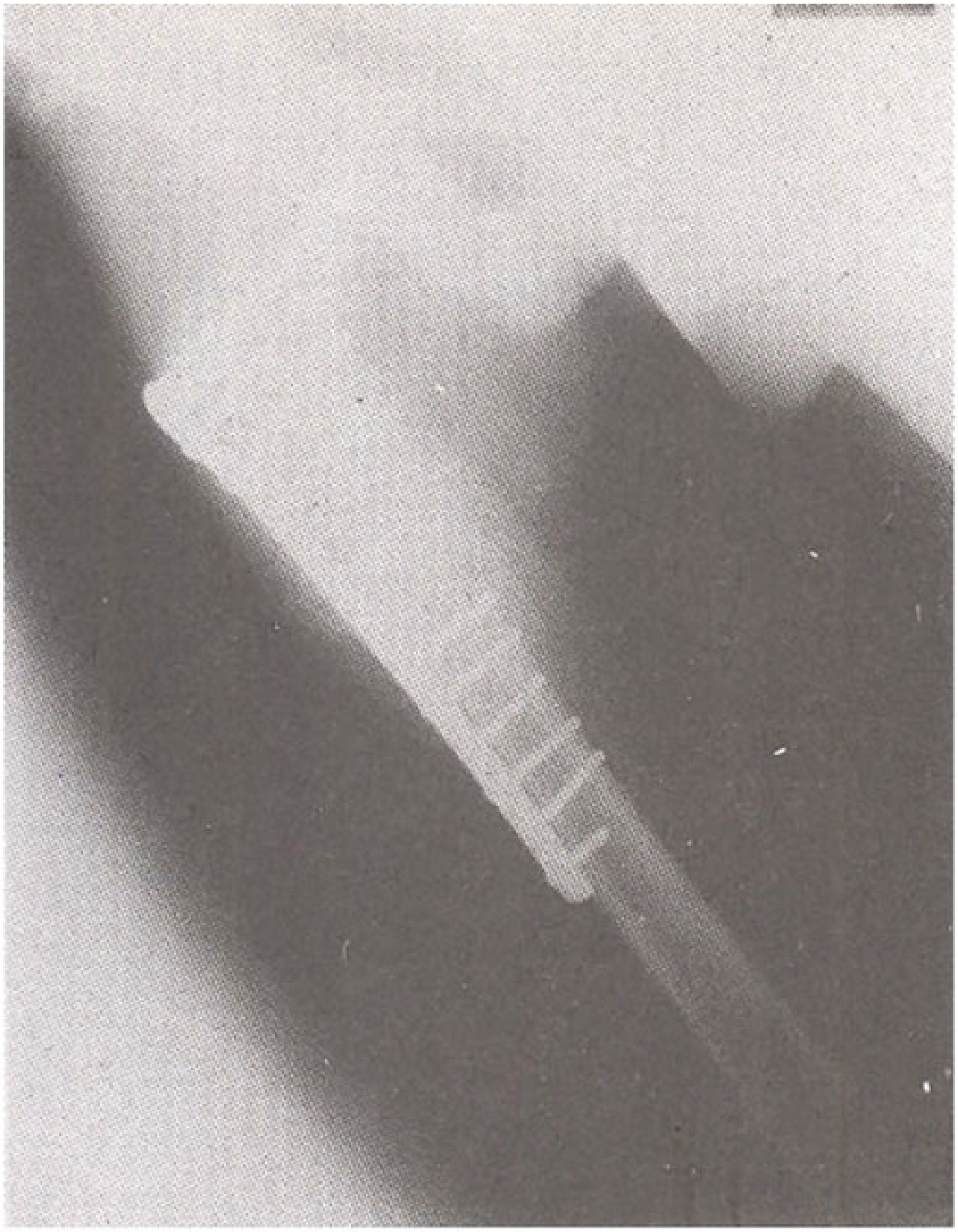

Figure 2-B: The fracture was debrided four times and then fixed with a reversed D.C.S. and bone grafted X-ray at 6 months showing good union.

The average time for union was 15 weeks. One Grade ifi B fracture of the tibia stabilised with a static external fixator went into delayed union. This was despite bone grafting and use of local muscle rotation flap. This fracture united after almost one year without further intervention. It is therefore, included in the union categoly. Three fractures went into non-union. One was a Grade III C fracture of the humerus which was stabilised with an external fixator after repair of the brachial arteiy and median nerve (Figure 3-A, B).

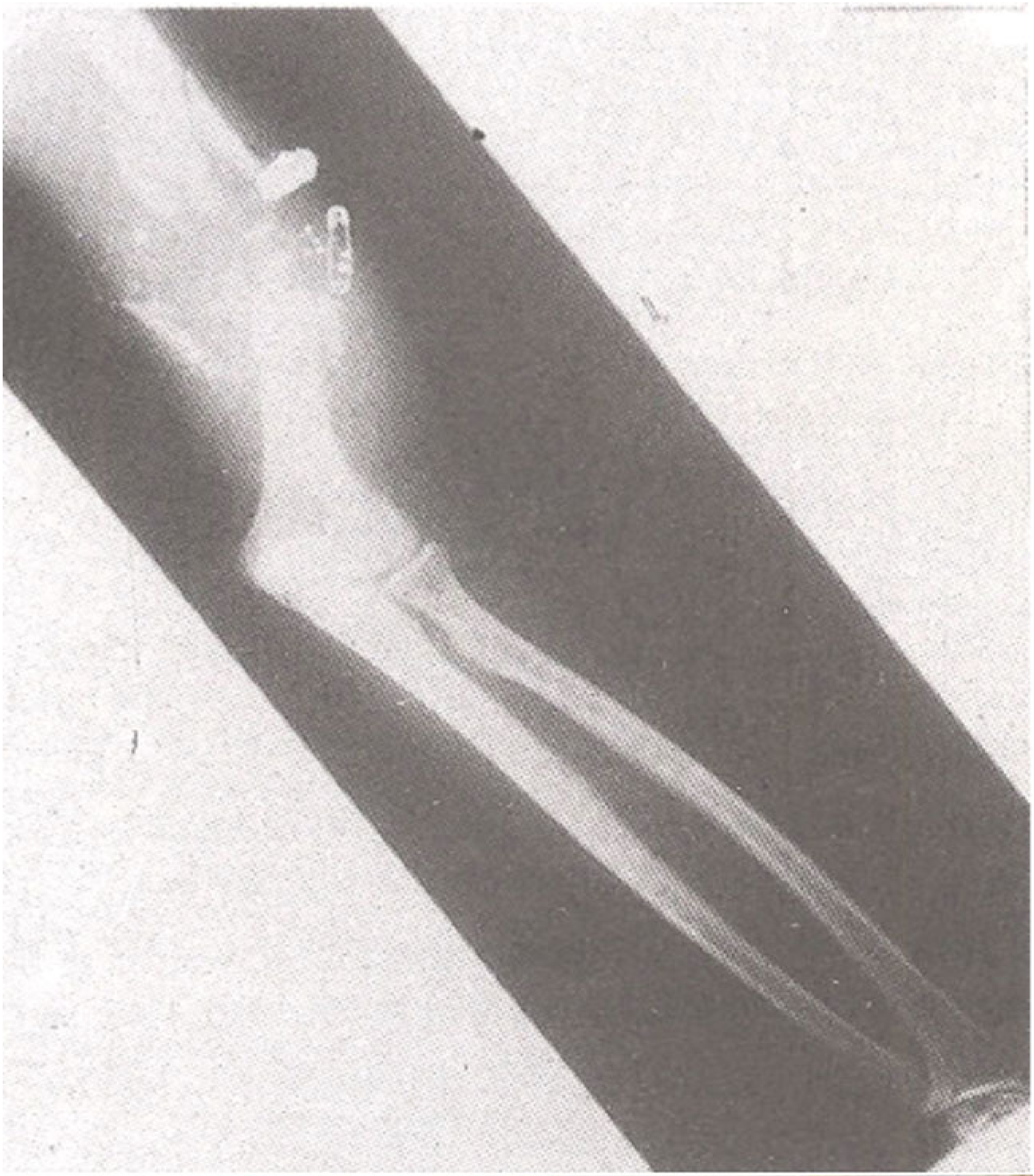

Figure 3-A. 22 year old male sustained a Grade IIIC fracture of the left humerus with injury to the median nerve also.

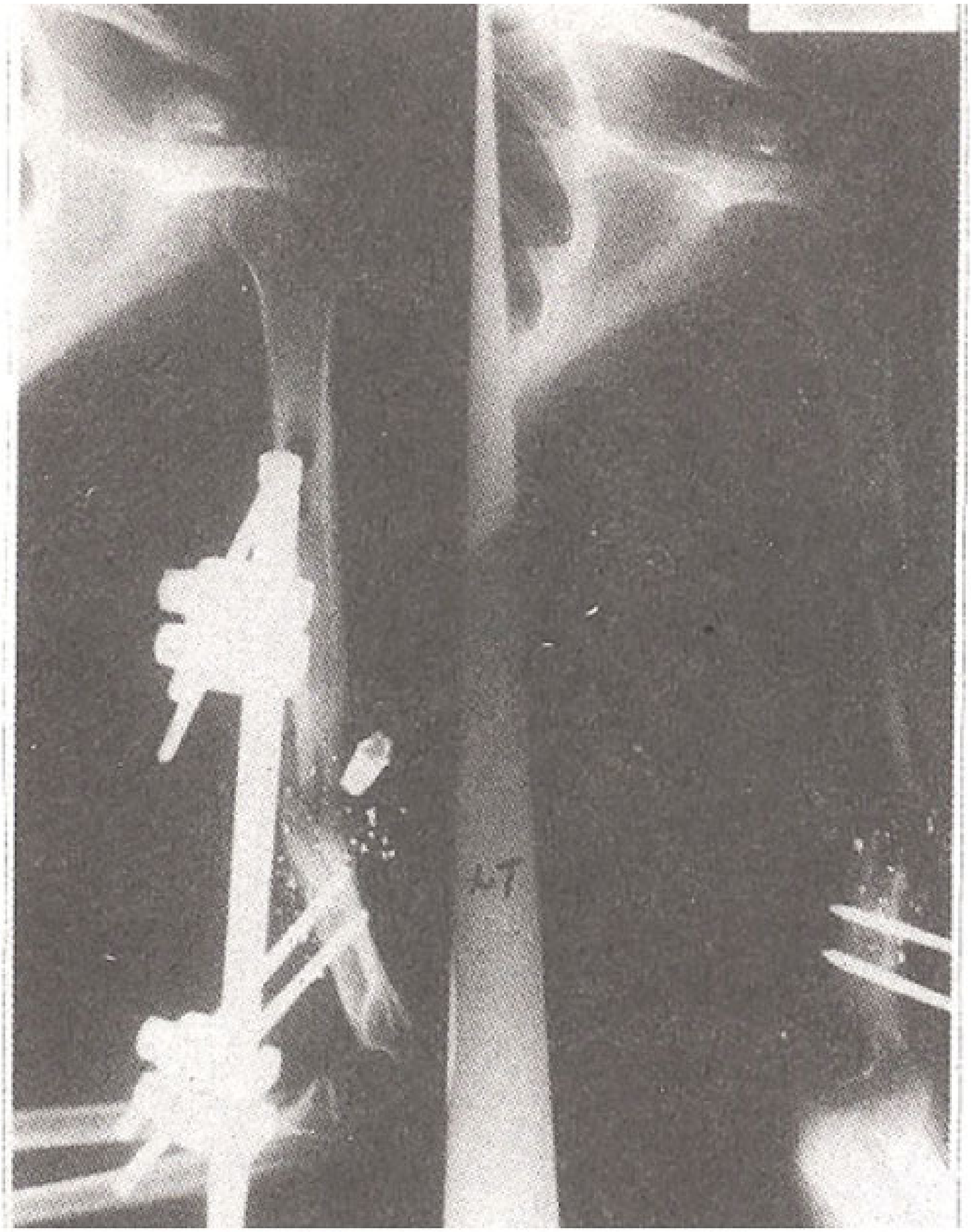

Figure 3-B. He was treated with arterial repair and stabilisation with an external fixator. He went into non-union and developed severe pin tract infection. The proximal pins spontaneously pulled out of the humerus.

The second was a Grade lilA fracture of the tibia also treated with external fixation. The third was a Grade III A fracture of the ulna treated with a DCP. One Grade III B fracture of the tibia in a diabetic developed osteomyelitis. The organism was Pseudomonas Aeruginosa. Complications are shown in Table.

Table. The complications encountered with the number of patients.

Complications	No. of patients
Delayed union	1
Non-union	3
Osteomyelitis	1
Pin tract infection	4
Severe fixator loosening	1
Seroma formation	2
Joint stiffness	1
Residual neurological deficits	2
Neuroma formation	1

Discussion

Open fractures aie a major challenge for eveiy orthopaedic surgeon. Gustillo's original article4 reported a 11.85 percent rate of wound infection. If grade III C are considered separately then infection rates of 50 percent and amputation rates of 50 percent are encountered[5]. Fractures caused by high velocity missile injury are a different type of open fracture. Most of the current literature[5] deal with the treatment of low velocity missile injuries. Many authors[10-12] advocate conservative approach for these wounds. Bnan, Long and Serocki1 recommend no debridement for low velocity handgun related Openfracture of the tibia. Ferraro and Zinar[13] are of the opinion that most civilian open fractures caused by bullets can be treated as closed fractures on an outpatient basis. Our experience leads us to state that low and high velocity missile injuries are two entirely distinct categories as far as treatment is concerned. Oestern and Tscherne14 graded all such injuries as grade III fractures. We fmd Gustillo's classification[4] to be prognostically useful and grade all fractures accordingly. We-treated all grade I and II open fractures with as aggressive a surgical debridement as grade III fractures. The difference comes in the number of debridements and the timing of internal fixation and wound closure, without need for soft tissue reconstruction. After this way of treatment, the grade land II fractures canbe treated like closed fractures and should have the same rate of complications. In grade III fractures the blast effect inside the limb is often surprisingly deceptive. A small ently wound can conceal a large blasted out cavity. Only when the wounds are extended, can the magnitude of the destructionbe appreciated. Debridement is thus the first factor affecting the outcome. At the first debridement, usually all the dead/dying soft tissue cannot be appreciated and this only becomes apparent at the subsequent debridement as progressive tissue death occurs. This meticulous cleaning sets the basis of eventual successful outcome. Sixteen of our patients needed more than three debridements before we could be confident that no further tissue death will take place. The soft tissue injury also plays a major role in determining outcome[1,3,15,16]. Our experience shows that this is truly significant for the tibia. Other

long bones and their surrounding soft tissues showed a remarkable ability to heal after adequate debndement. Almost all tibial fractures needed muscle flaps or grafts.
Prevention of infection is essential. This is determined by the amount of necrotic tissue generated by the energy transfer, contamination pushed into the wound, the adequacy of debndement, and the soft tissue coverage of the bone. Our use of antibiotics is thus more aggressive than is the practice as seen in the literature[4,9,17]. The reason for this is that we feel that after even the most meticulous debridement, some contaminants and dead tissue may still be left in the wound. Therefore, after internal fixation and wound closure we use antibiotics for 3 to 5 days. Our single deep infection was in a poorly controlled diabetic with a Grade III B open tibial fracture. His initial culture was Pseudomonas Aeruginosa. Infection in this patient was apparently related to loss of a muscle flap and subsequent poor soft tissue coverage. The role of bone grafting in cases of Grade III open fracture cannot be underestimated[17,18]. We bone graft all such fractures using autogenous bone graft. The ulnar non-union was a Grade III A fracture and was not bone grafted and this probably led to its non-union. All our other non-unions were in patients treated with rigid external fixation. External fixators are useful for treating severe open fractures and the fact that fractures treated this way had complications, should not be suiprising, as this also relates to the severe nature of the injury. However, we are now becoming convinced that the message conveyed by authors such as Gershuni and Halma[19] is very correct and external fixators do have inherent limitations. They reported an earlier time to union when the fixators used for tibial fractures were removed at 3.5 months. We feel they should be used for immediate stabiizationofafracture and if there is any evidence of delayed union then this should be either dynanüsed or converted to some other type of fixation. This was also reported by Rommens[20,21]. Though this technique does cany some risk of infection, enough evidence that it can be safely done is published. We as yet, have no experience with this technique. The stated objectives at the beginning were to assess the outcome of treatment at our institution and to identify variables to improve our outcome. Since the number of our fractures is small and the outcome of fractures of different bones and different techniques of fixation had to be grouped together, a statistical analysis is not possible because of the variables so introduced. Despite the high number of grade Ill fractures our complication rate is low and our union rate is good. One realization is the inherent limitation of the external fixator as a definitive means of fixation. This is the most major factor which we think affected the outcome negatively as almost all the complications encountered by us were related to the use of the external fixator. To improve the outcome, we would have to accept the advice of Gershum and Halma19 and Rommens[20,21] and revise the external fixator at a suitable time.

Recommendations

On the basis of our experience we can make the following recommendations:
1. Highvelocity missile injuries shouldbe identifiedand treated as different from low velocity injuries.
2. The softtissue injury mustbe staged accurately forthe need for soft tissue reconstruction.
3. Primary internal fixation and wound closure of Grade I and II open fractures can be done after debridement. I.V. antibiotics should be continued until five days after wound closure and all cultures being reported negative. The results should be identical to the results of the treatment of closed fractures.
4. Primaiy internal fixation and wound closure should be done in Grade!!! fractures only after careful consideration. Fixation and wound closure should wait until the wound looks cleanand cultures are negative. The only constantexceptionis a Grade Ill C fracture where a vascular repair has been done. The wound should however be left open.
5. Bone grafting is essential for Grade III fractures at the time of wound closure.
6. External fixation should be reserved for the most severe injuries and follow-up should be rigorous to help identify complications early. At the first sign of progression to delayed union, the fixator should be dynamized or the fracture should be internally fixed. This can also be done once all soft tissues have

healed, without waiting for the fracture to go into delayed union.

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