FOREARM FRACTURE TABLE FOR CLOSED NAILING OF FRACTURES OF SHAFTS OF FOREARM BONES IN ADULTS

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ABSTRACT: In the management of displaced forearm shafts fractures it is very important to regain the length of the bones, maintaining the radial bow, good apposition and alignment without any malrotation, early mobilization of wrist and elbow to get good results. Closed intra medullary nailing of these fractures can be considered as a good alternative method to the plating. We had devised the forearm fracture table which was very useful in getting a sustained traction reducing the clumsiness, difficulty, incoordination usually experienced in doing closed forearm nailing without the fracture table. In 8 out of 32 cases we could not get closed nailing, mini open nailing was done. In 23 cases where closed nailing was done all the fractures united with mean time for union 15 weeks. The average duration of post operative immobilization in the present study is 4.9 weeks, which ranged from 3 weeks to 8 weeks. The satisfactory and excellent functional results in 21 of 23 cases (91.2%) can be attributed to good and excellent anatomical reduction of the fracture, and early mobilization.

KEYWORDS: Forearm fracture table for closed nailing

INTRODUCTION: The fractures of the shafts of the forearm bones are the one of the most difficult fractures of the shafts of long bones ¹. The shortening, angulation, malunion, malrotation of either of these bones may result in a serious loss of elbow and wrist movements and pronation, supination of the forearm affecting the earning capacity of the individual as well as his day to day activities ². Even though the deformity may look minimal, the disability is very crippling. The rotations of the forearm, movements of the wrist and elbow help to keep the hand in space so that the whole upper limb can function properly. To avoid the crippling disabilities associated with these fractures, it is very important to regain the length of the bones, good apposition and alignment without any malrotation, maintaining the radial bow, early mobilization of wrist and elbow ³. Any compromise in these will definitely not give good results.

Open reduction and internal fixation with dynamic plate and screws is considered the best method to treat the displaced fractures of shafts of forearm in adults ⁴. But this technique is very invasive with big operative wounds and big non-cosmetic scars. The risk of refracture after the removal of plates & screws is between 4-25% ^{5, 6,7,8,9}. Closed intra medullary nailing of these fractures can be considered as a good alternative method. The procedure is minimally invasive and preserves the whole biology of fracture healing ¹⁰. Intra medullary nails are load sharing devices and there is secondary bone healing with good callus ¹¹, hence may not need cast immobilization after nail removal. The nail removal is also involves small incisions.

So the present study was undertaken to evaluate the results of closed intramedullary nailing for diaphyseal fractures of the forearm bones in adults. In this study the anatomical reduction of the fractures, rate of union, time taken for union, the complications, the functional results in terms of forearm rotations and wrist and elbow movements are studied and the advantages and

disadvantages of the procedure are also evaluated. We used a unique indigenously made radiolucent forearm fracture table to give continuous traction and counter-traction to reduce and maintain the fracture during surgery (fig.1.)

MATERIALS AND METHODS: The present study was a prospective study. The inclusion criteria for the study are a) the patients aged above 18 years. b) Closed diaphyseal fractures of the radius or/and ulna with at-least 5 cm of intact proximal or distal bone. c) Compound fractures - type-I Gustilo and Anderson classification¹². d) Segmental fractures of forearm bones. e) Poor skin conditions (Example, Burns). f) Polytrauma patients. In the present study the patients with open epiphysis (the patients below 18 years) were excluded. The Monteggia and Geleazi fracture dislocations were excluded because here the dislocation of the proximal and distal radio-ulnar joints also contributes to the final outcome along with the fracture of ulna or radius. Fulfilling the above criteria about 32 consecutive patients were selected for the study. These fractures of the forearm are classified according to the AO classification. The open fractures are classified according to Gustilo-Anderson classification.

All these patients were subjected to closed intramedullary nailing - using the Talwalkar's square nail under the image intensifier using forearm fracture table. In 8 patients we were forced to do open nailing due to difficulty in obtaining satisfactory closed reduction. One case lost to follow-up. These cases were excluded from the study and the totals of 23 cases (43 fractures) were considered for the final study.

In the present study an indigenously devised forearm fracture table was used. This radiolucent fracture table can give the traction and counter traction necessary for closed reduction of the fracture. After giving adequate traction & counter traction, the surgeon reduces the fractures under image intensifier and the assistant hits the nail through fracture site into the opposite medullary canal. As only one assistant is needed, the crowding around the table is not there and the incoordination between the team is minimal (fig. 2). We have used fracture table in all our cases.

A 1.5 cm incision is made just lateral to Lister's tubercle at the distal radius and interval between the short and long radial wrist extensors was entry point. The point of insertion of the nail for ulna is 5mm toward radial side of the tip of the olecranon because the ulna bows towards radius in the proximal third (fig. 3). Both the radius and ulnar nails are negotiated just in short of the fracture site. Then the surgeon reduces the fracture and the nails were hit into the opposite medullary canal by the assistant and confirmed by the image intensifier. Medullary canal reaming was not done. Holding the forearm in proper rotation before the nail is impacted in to the opposite medullary canal is very important to get the best possible rotational reduction of the fractures. We routinely used nail diameter of 2.5 mm or 3 mm during the procedure.

In 8 cases the closed reduction could not be achieved so as to introduce the nail in the opposite medullary canal. When closed reduction was not achieved inspite of repeated trials, open reduction was done. The causes of inability to achieve closed reduction were the time period beyond 1 week between the injury and surgery, soft tissue and muscle interposition, comminution where a fragment blocking the entry of the nail in the opposite medullary canal. Once the nails are introduced into the opposite medullary canal, the nails are hit till the other end of the nail is buried adequately in the bone so that the irritation at the wrist and elbow are to be avoided. The rotational stability was checked after the procedure under image intensifier with elbow flexed to 90°. After a

thorough wash, the wounds were closed, sterile dressings applied and tourniquet removed and above elbow slab applied.

The patients were on single dose of intravenous ceftriaxone pre operatively and oral antibiotics till 48 hours. Check x-rays were taken in both antero-posterior and lateral view. The wound was inspected after 48 hours and above elbow slab applied with minimal dressing and the patient was discharged if the patient did not have the associated injuries requiring continued stay in hospital. The patient is discharged with oral antibiotics (if necessary), analgesics and anti-inflammatory drugs for 5 days and active finger movements and shoulder range of movements exercises. The first follow up is usually on 13th post-operative day. The sutures were removed and another snugly fitting above elbow cast applied. At the end of 4th week, in most of the patients above elbow cast was removed. The wrist and elbow range of movements started but rotatory movements were avoided for further 2-3 weeks. Then the patient is reviewed every 2 weeks interval till the fracture union and every 3 months after the union. In each follow-up the signs of clinical and radiological signs of union were noted. Radiological union was considered when there is adequate bridging callus was seen. The clinical union was considered when there is minimal or no tenderness at the fracture site and the patient can use the forearm without pain. Reduction of the fractures are evaluated by following criteria as excellent when there is anatomical alignment, good when there is slight step formation or angulation not exceeding 10° but no rotational deformity or synostosis at fracture site, as poor when there is angulation of more than 10° and / or rotational deformity or synostosis at fracture side. The functional results are evaluated according to Anderson's criteria ⁵ as excellent when union with less than 10° loss of elbow and wrist flexion / extension and less than 25% loss of supination and pronation, as satisfactory when union with less than 20° loss of elbow or wrist flexion / extension and less than 50% loss of forearm rotation, as unsatisfactory when union with greater than 30° loss of elbow or wrist flexion / extension and with greater than 50% loss of forearm rotations and as failure when non-union or unresolved chronic osteomyelitis.

RESULTS: The total numbers of cases fulfilling the inclusion and exclusion criteria were 32. All these 32 patients were subjected for closed intramedullary nailing using forearm fracture table. Out of these, in 8 cases closed reduction could not be achieved, so open reduction was done. One patient lost to follow up. These cases were excluded from the present study. Total number of cases considered for the study was 23 cases.

In the present series, the age distribution ranged from 22 years to 75 years. Majority of the patients were below 40 years. The mean age was 39.4 years. There were 16 (69.5 %) male patients and 7 (30.4%) female patients; male to female ratio was 2.3:1. Right side forearm bone fracture was found in 11 patients (47.8%) and left was in 12 patients (52.2%). The road traffic accidents were the commonest mode of trauma, 13 out of 23 cases (56.5%). Fall on outstretched hand in 8 patients (34.7%), industrial accident in a patient (4.3%) and one patient with assault (4.3%). In 13 of 23 patients (56.5%) the mechanism of injury is direct trauma. Direct trauma is seen in most of the RTA cases i.e. 9 out of 13 cases of RTA (39.1%) and 2 of 8 cases of fall. The rest of the direct injuries are produced by assault, industrial accidents. Indirect trauma in the present series is seen in 10 patients of 23 cases. Indirect trauma is seen in 6 of 8 cases of fall on outstretched hand and 4 of 13 cases of RTA. In the present study, the mid third part of the diaphyseal region was the commonest site of injury in 35 of 43 fractures (81.3%). The lower third part of the diaphyseal region was involved in 8

of 43 fractures (18.6%). None of the fractures were seen in upper third shaft of either radius or ulna. In the present study 13 out of 23 cases (56.5%) were of A3 type i.e. Simple fracture of both radius and ulna. Wedge fracture of both bones (B3.3 type) was of second common type of fracture seen in 4 of 23 cases (17.2%). In two cases fracture shaft ulna associated with the segmental fracture of radius (type C2). There were two cases of isolated radius (type A2) and a case of isolated ulna (Type A₁). Seven of 23 cases (30.4%) were compound grade 1 fractures of forearm bones. In this series, most of the patients have (86%) fracture of both the bones of forearm. Only 2 (8.6%) patients had fracture radius alone and one patient (4.3%) had ulna fracture alone. The associated injuries noted were, rib fractures in one patient, Ipsilateral fibula and scapula fracture in one patient, Ipsilateral metacarpal and phalangeal fractures in two patients, opposite shafts of femur, tibia and fibula fractures in one patient, Ipsilateral shafts of femur, tibia and fibula in one patient, opposite side fracture distal end radius in one patient, nasal bone fracture in one patient. In the present study of 8 patients (37.7%) had associated musculoskeletal injuries.

The maximum duration between injury and surgery in the present series where we could do closed reduction and nailing was 9 days. The mean duration between injury and successful closed nailing in the present series is 5.1 days. Of the 23 cases of this study, in 6 cases (26%) the closed reduction took 40 to 70 minutes, in the remaining 17 cases less than 40 minutes. In the present study most of the cases were immobilised for 4 weeks or less in 13 of 23 cases (56.5%). Rest of 10 the cases were immobilised for 5-8 weeks. None of the patients were immobilised for more than 8 weeks. The mean period of immobilization was 4.9 weeks. In the present study we have not come across non-union. There was no need for any second surgical procedure like bone grafting in any of our cases. There were 2 cases of delayed unions. One case was segmental fracture of mid third radius with mid third ulnar shaft fracture. In this case the above elbow cast immobilization was done for 8 weeks and later active range of motion physiotherapy started. The fracture had united at 24 weeks. In another patient who had delayed union, there was comminution at the fracture site (butterfly fragments) of both bones in mid third shafts. The fracture was grade I open fracture. In this patient also union was obtained at 24 weeks. In 3 cases superficial infection was noted which was healed with systemic antibiotics. In one patient, there was bursa over the radial nail insertion site. In one case tourniquet palsy was observed. There was complete recovery in 6 months. In one case, osteolysis at the ulnar nail tip was observed.

In the present study 8 of 23 (34.7%) patients union is obtained in 12 weeks and 9 of 23 cases united in 12 to 16 weeks, 4 cases united at 18 weeks. Two cases united at 24 weeks postoperatively. The time taken for the union in the present study ranged from 12-24 weeks, mean being 15 weeks.

The average duration of post operative immobilization in the present study is 4.9 weeks, which ranged from 3 weeks to 8 weeks. The duration of immobilization is mainly determined by the type of fracture, rigidity of the fixation, site of the fracture, reliability of the patient. We have mobilised the patient after a minimum of 3 weeks of above elbow cast. The mobilization is done independent of the radiological appearance of callus. In single bone fracture the limb was immobilised for 3 weeks. In most of the uncomminuted fracture of mid third shafts of both bone fractures were immobilised for 4 to 6 weeks. In the comminuted fractures, segmental fractures the period of immobilization ranged from 4-8 weeks. The duration of follow up was ranging from 18 to 30 months.

In eleven out of 23 cases the reduction was excellent and in rest of the 11 cases the reduction was good and in one case the poor result was due to angulation at the fracture site. Most of the good results in the present series are due to obliquity of the fracture which resulted in slight step formation which obviously will not reduce in anatomical position by closed methods. The radio-ulnar synostosis was not observed in any of the cases.

In the present study the Anderson's criteria ⁵ were used for the functional assessment. In our study excellent results were noted in 16 patients (69.5%), satisfactory in 5 cases (21.7%), unsatisfactory results noted 2 patients (8.6%) and none had poor results.

DISCUSSION: The treatment of displaced fractures of shafts of radius and ulna is primarily operative. The closed reduction and cast immobilization for the displaced fractures should only be taken if there is a specific contra indication to operative treatment ³.

The A.O. group has reported successful use of compression plate and screws in the forearm shaft fractures. Since then it is one of the widely used and well established method of treating forearm bone fractures.

The advantages of the plate and screw fixation are that, the reduction is done under direct vision; the plates are applied so that there is compression at the fracture site. Bone grafting can be done if needed. The fixation is rigid, so post operative immobilization in cast is most often not needed. The disadvantages being, the risks of any open surgical fixation, that is increased chance of infection, disturbance of the soft tissues, periosteal stripping, and evacuation of fracture haematoma. One important disadvantage is the risk of refracture after removal of the compression plate, which necessitates the forearm being protected in splint for 6 weeks and from severe stress for 6 months.

Mechanically intramedullary nails offer several advantages over the plate and screw fixation ¹³. Intra medullary nails are subjected to smaller bending loads than plates and are least likely to fail by fatigue. The reason is that they are closed to the mechanical axis than usual plate position on the external surface of bone. Intra medullary nails act as a load sharing devices in fractures with cortical contact. Stress shielding with resultant osteopenia commonly seen with plate and screws is minimized with intramedullary nails. Closed intra medullary nailing is definitely having a lot of advantages over the other modalities of treatment ^{2,10,14,15}. It is a minimally invasive procedure requiring shorter operating time. The biology of the fracture healing is not disturbed. Bone grafting is usually not needed ². Risk of infection is minimal. It is economical to patient due to decreased hospital stay and cheaper implants and minimal use of antibiotics. Since secondary bone healing is expected there is no need of immobilizing the limb after the nail removal and the risk of re-fracture is minimal. The procedure is very cosmetic in nature.

Manual traction & counter traction method is used in the previously published closed forearm nailing techniques¹¹, where assistants give traction and counter traction, the surgeon manipulates the fragments to reduce the fracture. This method is very cumbersome. The co-ordination is must between the surgeon, who reduces the fracture and holds it and the assistants who give traction and counter traction and another assistant to hit the nail through the fracture site into opposite side medullary cavity. A surgeon, assistants and scrub nurse with image intensifier in between - too much of crowding around the table.

Forearm fracture table is a very interesting device used in the present study. It is radiolucent. Traction is given by cloth made stripes (which can be autoclaved) applied to hand which

in turn attached traction device. The counter traction is given at elbow by a vertical pole on fracture table. Forearm can be held in adequate traction in desired rotation of forearm. Adequate working space is available circumferentially around the forearm due to the 3 inches elevated elbow and wrist rests. The same fracture table can be used for either left or right side forearm. The forearm fracture table can be fixed to any standard operating table using clamps. The fracture table is padded adequately at pressure points. It can be very conveniently draped with sterile cloth towels. We found the device very useful in getting a sustained traction in a desired rotation of the forearm. The clumsiness, difficulty, and incoordination we had experienced in doing closed forearm nailing without the fracture table earlier were significantly reduced. Ours is the first published forearm fracture table used for closed forearm nailing.

Out of 32 cases, in 8 cases we could not get the closed reduction, so abandoned the procedure and open reduction and intramedullary nailing was done. In 5 of these cases, the duration between the injury and surgery was more than 1 week. In one case there was soft tissue interposition between the fracture fragments preventing the closed reduction and in one case it appeared that the comminution at the fracture site must have blocked the medullary canal thus leading to failure of closed nailing. In one case the cause could not be found.

It is important to note that in the present study all the fractures were united and non-union was not observed in any case. Delayed union was noted in two cases. The union is said to be delayed when the healing has not advanced at the average rate for the location and type of fracture (Usually 3 to 6 months). In the two cases of delayed union, which united by 24 weeks, one was segmental fracture of the shaft of radius and uncomminuted fracture of ulna. The cause for the delayed union in this case can be attributed to the avascularity of the segment of bone which must have been stripped off of its soft tissues at the time of injury and during surgery. The other case of delayed union was the open type-I Gustillo-Anderson with butterfly comminution of both bones. The above cause can be attributed for this case also.

The time taken for the union in the present study ranged from 10-24 weeks, mean being 15 weeks which is comparable to other standard studies by Talwalkar A.K. et al.¹⁶ 20 weeks, Street D.M et al.¹⁵ 18 weeks, Moda S.K. et al.¹ 15 weeks, Patwa et al.¹⁴ 12 weeks, P Visna et al.¹⁷ 14.2 weeks. About half of our cases have united by 14 weeks. Moerman J et al.¹⁸ noted union time with intra medullary nailing shorter than other techniques.

Moda SK et al.¹ reported the reduction of the fracture as, excellent in 70%, good in 20% and poor in 10% cases. Marek et al.¹⁹ reported anatomical excellent results in 50% cases, good in 27% cases and poor in 22.2% cases. P Visna et al.¹⁷ reported excellent reduction in 80%, good in 20% cases and poor in 4% cases. The results in our study are comparable to these previous studies.

The satisfactory and excellent results in 21 of 23 cases (91.2%) can be attributed to good or excellent anatomical reduction of the fracture, and early mobilization. A case with poor anatomical result due to angulation at the fracture site more than 10° – had satisfactory results. One of the 2 cases of unsatisfactory results was a segmental fracture radius with non comminuted fracture of ulna. The reduction was good. The fracture united at 24 weeks (delayed union). The period of immobilization was 8 weeks. The causes for unsatisfactory functional result can be attributed to the type of fracture, long period of immobilization and delayed union. In the other case graded as unsatisfactory result, the fracture was grade-I open fracture with butterfly fragments of both bones. The reduction was good, needed immobilization for 8 weeks and united at 24 weeks (delayed

union). Here also the same causes as the other case can be attributed for unsatisfactory results. The functional results of this study are comparable to the studies of street DM et al.¹⁵ and Patwa et al.¹⁴. All these studies had 83% to 92% of excellent to satisfactory results. Nadeem A Lil et al.¹¹ concluded that complications associated with square nails were less compared with plates and interlocking nails. In none of our cases there was a necessity of nail removal and was not done at the time of last follow up.

The small numbers of the patients, retrospective and non comparative nature are the limitations of the present study. The fracture table devised for this study need to be improved and certain modifications are to be made.

CONCLUSION: Displaced fractures of shafts of forearm bones are one of the challenging. Closed intra medullary nailing for these fractures is very good alternative procedure to plating. The forearm fracture table is very useful and convenient device helps to get a good maintainable reduction of the fractures during the procedure.

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Figure 1: Forearm fracture table which is radiolucent can give traction - counter traction is very helpful for closed nailing forearm bones fractures.

Figure 2: Fracture table can give sustained traction in desired forearm rotation makes procedure less clumsy and well coordinated.

Figure 3: Less invasive procedure, very cosmetic incisions.

Figure 4: Very good range of movements of elbow, wrist and forearm rotations.

Figure 5: Pre operative, immediate post operative, 7th week Post- operative and after union radiographs of the patient.

Figure 6: Pre operative, post operative radiographs with good fracture reduction and radiograph after union.

Figure 7: Good post operative reduction of the fractures and well united fractures.

Figure 8: Pre operative and well reduced fractures in post operative radiographs.

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