INTRAMEDULLARY NAILING TREATMENT OF FEMORAL SHAFT FRACTURES IN ADULTS

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MOSLEHUDDIN AHMED

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I. T I T L E

The history of human progress is a series of tales, attempts, failures, persistence and ultimate success of the great discoverers, and inventors, who lived, laboured, and died for the sake of humanity. It is for their ceaseless toils and tireless struggles that man has marched from cave to the cabin. The achievements of those pioneers have illuminated the progressive conditions of scientific set up, including medical science advancement. The world pays highest tributes to those scientists, physicians and surgeons for their abnegations, for the benefit of mankind.

From the beginning of civilization, to treat the fractures of the shaft of the femur was a burning problem, how to manipulate and reduce the fracture properly, and, how to obviate prolonged immobilization and functional disability of the limb. Many endeavours had been strived for the better, concrete results, but none of it could hold footsteps.

At last, it has been accepted that the internal fixation is the better method for the treatment of femoral shaft fracture in adult. But it is also unanimously decided that "THE INTRAMEDULLARY NAILING" is the accredited best internal fixation method for adults in all respects.

"The intramedullary nailing is the treatment method for the shaft fracture of long bones, where a nail, made of highly tempered, electrolytically inert metal is inserted into the medullary canal of the bones, for stable and perfect osteosynthesis and union".

II. INTRODUCTION

The main idea to treat the fracture of the shaft of the femur is that, the union of the bone should be perfect with the restoration of normal plane of functions of the limb, and joints above and below the fracture, retaining the anatomical contour. It is applicable to other fractures too. Failure to do so means, a favourable chance is being made for the development of osteoarthritic changes in the joint.

In other methods of treatment, the anatomical and functional results are not so perfect as in intramedullary nailing. Besides that, patient is to stay in the hospital for a prolonged period causing mental depression to the patient, also jeopardizing the social and economic life. At the same time, due to prolonged and imperfect immobilization, there will be permanent disability of the limb - muscular atrophy, non union, delayed union, malunion, and stiffness of the knee joint. Even with plating, external reinforcement is necessary, keeping the patient in a state of recumbency for a long period, depriving the patient from his normal life.

Truth will always prevail. The authenticity of the end good result of intramedullary nailing has been bloomed in different parts of the world. Even the roaring critic voice of the skeptic type of surgeons has come down to the point of silence as their criticism was nulled and voided by the magnificent performance of the nailing. Intramedullary nailing has got preponderant merits, and efficacy, than other internal fixations. It has also been proved that the intramedullary nailing is the unique method, and is immune to post-operative

sequelae of the femoral shaft fracture, if the operation is performed perfectly.

Hugh Smith has advocated and praised this method categorically, and alluded to apply to a great array of interesting cases - namely fresh fractures, delayed and non union cases, malunion, the bridging of the decects, pathological fractures, dysplasia, and severe type of osteoporosis.

It was a wrong impression that the nail is a foreign body in the medullary cavity, so it will interfere in the process of healing of fractures. But the plausible proof is that, nailing does not interfere in the process of healing of the fractures.

By other methods, union can be achieved but could not collocate the requisite demands of a normal limb. On the contrary, the union can be achieved with normal preservation of functions, and anatomical shape of the limb, by intramedullary nailing. It also curtails very much the period of recumbency leading to a normal life of a patient within a very short time.

It has been postulated by Gerhard Küntscher that the shearing strains imposing upon the fracture site, will be converted into compression strain as the nail lies in the long axis of the bone. The nailing eliminates all detrimental factors. The compression strain exists, enhancing the formation of callus. In intramedullary nailing, valuable advantages are, the external reinforcement or support of the limb is not necessary, and early weight bearing brings the two ends of fracture more accurately and perfectly, so the osteosynthesis

is discernible.

Previously, it was believed that introduction of nail into medullary canal means, introduction of infection. But, scarcely, it can materialize its influence, because, surgeons are very much aware of taking all sorts of sterile measures and antiseptic precautions. Also, in this age, antibiotics play a good role to preclude the infection. So infection is not a problem, and now, hardly infection can peep through this operation.

Infection is deemed to be one of the causative factors of non union. But Watson Jones states "non union is a complication of the past".

On the basis of rationality, sepsis, after the plating is more possible, because, the operation may consume much time and sometime for the better exposure of the shaft a long incision is necessary, demanding more muscular exertion.

In plating, two tables of cortex are bored in and around the fracture. So, the stability and compactness of the cortex are disturbed causing the cortex porous, and weak. The plate occupies a large space of cortex in a close contact, disrupting the periosteum and periosteal vessels of that area. The area is deprived of blood supply. Also, during screwing some of the medullary vessels may be damaged. If double plates are used, then blood supply of that area of cortex will be throttled. Now, the question comes of disturbed healing process due to less blood supply causing delayed or non union and there may be secondary fracture.

During intramedullary nailing, the nutrient artery may be damaged, but no evidence of hindrance is shown in accumulation of callus, in our series.

Besides that, the osteosynthesis is not so stable and perfect by plating and screwing in the femoral shaft fracture, so the completion of osteogenic activity of the union may be delayed. These sorts of internal fixations are also exposed to actually tremendous contracting forces of powerful muscles of the thigh and are subject to fatigue. This fatigability and powerful contraction of the muscles, in many occasions, evoke bending or breakage of the plates and screws.

Over and above, the nailing prevents the angulation, lateral displacement, and, osteosynthesis will be stable provided the qualities and quantities of the nail are perfect. In comparison, the extraction of nail is also simple and more easier process than the extraction process of plate and screw.

Prolonged splinting of the fracture may invite delayed union. It often keeps the patient in recumbency, and depredate the functions of the joint. The cause of this undesirable hindrance can be depicted in two ways. These factors are extra-articular adhesions and intra-articular adhesions. This intra-articular adhesion impelled the knee joint more towards stiffness. Once adhesion is established, it is ridiculously impossible to irradicate the stiffness.

Just to overcome the resistance of the muscular spasm, and to bring the two fractured ends in apposition

skeletal traction for few days has got immense value. But prolonged period of traction causes overpull or distraction. If this is allowed to exist, loss of muscle tone or the interposition of non-ossifiable material may lead to non or delayed union.

Charnley's view is that, good knee function following femoral shaft fracture depends upon early union. But, early active movement of the limb and early union can render the service well, to bring back the normal functions of the joint. But under no circumstances it is possible to yield union to femoral shaft fracture within a very short time nor with any other promiscuous method. But the appraisal of intramedullary nailing can be determined, by infliction on perfect stable osteosynthesis following early union.

Femoral shaft fracture reduced by surface or skeletal traction or by manipulation followed by immobilization in plaster will not be compensating accurately, and perfectly. It has been found, the end result is either malunion or non union; associated with restricted knee movement, and almost every case eventually comes to open reduction --namely the intramedullary nailing.

Osteosynthesis due to intramedullary nailing expedites the callus formation, and this osteosynthesis encourages the patient to move limb actively. It is expedient to tell that the intramedullary nailing has got clear expositions, and activities. Lorenz Böhler has enunciated, "Medullary nailing is vastly superior to all previously known methods for the treatment of fractures of the femoral shaft".

III. HISTORY OF INTRAMEDULLARY NAILING

The achievement of proper treatment of the femoral shaft fracture is very painstaking, a story of perseverance of so many who reached the destination by their intellectual excogitations and methodical efforts.

Hippocrates and his followers used to reduce the fractures by manual manipulations. It was practised for many years but could not achieve desired result.

The continuous traction, for the treatment was introduced in 1305 by GUY DECHAULIAC, and henceforth, the treatment has been adopted with its tremendous influences and refinements. Still, this method has got some unavoidable sequelae, joint stiffness, muscular atrophy, and general disability, due to prolonged recumbency. It was widely used before the evolution of plaster of paris.

Key, Conwell have advocated this method with a plea of some mobilization of knee and full range of movement of ankle joint. The disadvantages are, prolonged period of recumbency, constant supervision, and frequent adjustment of weight, and limb. The end result of many cases came out as a non or delayed union case. Non union due to distraction is blamed by "Böhler"; and infection at the site of traction may be the source of menace.

Since the advent of plaster of paris, orthopaedists tried the treatment with this new light of success. But this method alone was very cumbersome and very difficult to

maintain the proper alignment, causing many hazards.

An allied method, by the combination of continuous traction till the callus is accumulated at the fracture site, followed by reinforcement with plaster of paris was tried for a period, but failed to have satisfactory results.

Originally, the external skeletal fixation was introduced by BONNET in 1870, followed by Parkhill and Lambottee around the turn of century. It was also difficult to maintain the exact weight for proper traction, and other paraphernalias, and complications also did not spare this method. After that, many devices have come into action but the Haynes, the Roger Anderson, and Stader apparatus have given more useful service for the adjustment of this method. Russell apparatus, Thomas splint, and Böhler's modification of Braun splint have given some contributions to this method. This external skeletal fixation method has been tried with the collaboration of plaster of paris, and still this combination method is practised, but not free from complications.

Roger, in 1827, had attempted open reduction and wire suture fixation, but, this method did not gain acceptance till the concepts of antisepsis and asepsis are improved in surgery.

No method was in perfection, so endeavours were going on with full swing for better method.

In 1905, LANE first instituted the internal fixation, by plate and screws, supericrity had been proved to wire suture. Those plates and screws were acting misohiveously

by resorption of bone, around the plate and screws, followed by the most unwanted complication for the surgeon - the infection. Being perturbed and annoyed he had uttered, "rarefying osteitis, in plain English means, dirty surgery".. So he began to follow the "Non-touch" technique which gave better result but could not stop resorption.

But, at last, the dark corner of treatment was pierced and focussed by the new light of unprecedented method, "THE INTRAMEDULLARY NAILING". In the latter part of nineteenth century the new chapter of treatment of fracture opened. In 1897, NICOLAYSEN published one paper about intramedullary nailing, followed by DELBET in 1906, and LAMBOTTEE in 1913. Delbet practised the internal fixation of the neck of the femur. Lambottee's performance was to fix the small fragments of bone by means of thin nail. He also treated subtrochanteric fracture of femur by means of a long screw. Lambottee also practised the axial method of osteosynthesis of clavicle since 1907.

The intramedullay nailing inspired the surgeons of every corner of the world, to practise this method and to find out the pros and cons of the method.

In the second decade of this century different materials were used as a nail - ivory, beef bone and human bone (Hugland, 1917), but none could render appreciable result.

For some period nailing was in cold storage. But in 1918, HEY GROVES alluded to it and revived this method. He had opened the curtain of secret of nailing, by using

massive nails in the medullary cavity. This procedure was criticized bitterly as bony union was not good, due to resorption of the bone.

MENEGAUX in 1934, ODIETLE, and MOYSE advocated that probably the bone resorption was due to electrolysis of metal.

VENABLE, STUCK, and BEACH (1937) conquered this problem. Three years after they proved it and consistently enunciated that electrolytically inactive metal can preclude the resorption of bone. So the research was going on to find out metal, which will be benign to bone and other tissues. At last, biologically inert alloy, steel and vitallium were selected. This achievement again brought hope in despair.

In the year 1937, and 1939, in America, L.V.RUSH and H.L. RUSH presented entirely a new technique of longitudinal fixation of ulna by means of steinmann's pin. They deliberately used to keep the end of the pin off the skin, with a motive of extracting it out after few weeks. The efficacy of this method was criticized by Watson Jones.

LAMBRINUDE of England, in 1940 used kirschner wire in intramedullary nailing. He followed the same procedure of Rush. It was followed by Joly and Devis of Belgium.

In 1940, GERHARD KÜNTSCHER of Kiel, Germany, triumphed over this matter and established the superiority of intramedullary nailing. Küntscher displayed the unique result of intramedullary nailing - one of the controversial difficult problem which was swinging like a pendulum has been solved by him magnificently.

His first paper was published in March, 1940, "Deutsche kongress fur chirurgie". He performed the operation by longitudinal fixation extra-articularly, and used strong metallic rod, occupying the full length of medullary cavity of the femur.

At first, Küntscher's procedure was criticized as "anti physiological method", but soon the reality and rationality of intramedullary nailing encouraged Scandinavian, Dutch and German surgeons, and later, surgeons of other countries to perform intramedullary nailing in shaft fracture of the femur.

In the World War II, this intramedullary nailing sceptically performed by other surgeons in selected cases of femoral shaft fractures, but its miracle performances and its end result charmed them immensely. They admired this intramedullary nailing with acceptance and recognition.

Küntscher and some other surgeons are in favour of closed method, because, to avoid infection and favourable callus formation. But, it is experienced by other surgeons that large number of disadvantages of the closed method out-weighed its small number of advantages. So, Küntscher's closed method suffered bitter criticism. They also postulated that those complications of closed method are preventable by open method. AUSTIN MOORE remarked, "I have come to the conclusion that I will expose the fracture site in all cases in the future".

IV.ANATOMICAL PECULIARITIES OF THE FEMUR

The femur is the strongest, the longest bone in the body. It is also a weight bearing bone. The bone has got forward and outward curvature of its shaft, so do the thigh. These curvatures help for propulsion and for the maintenance of posture and equilibrium. The posterior concavity is supported by a strong ridge, linea aspera. The neck has made an angle of about 128° with shaft, named neck shaft angle.

The above mentioned peculiarities are important in the treatment of shaft fracture. Failure of restoration of this anatomical contour will result deformity and disturbance in transmission of body weight.

The diameter of the medullary canal is not symmetrical throughout its length. There is one constriction called isthmus, at the junction of upper and middle third of the shaft. The diameter of the upper and lower part of the medullary canal is greater than the other part. The measurement of the medullary canal plays an important role in nailing.

In cross section, the canal is oval in most cases. The sagittal diameter is greater, on the average, by two to three mm.

Another peculiarity is that, young athletic individuals generally, have rather narrow canal with thick cortex. On the contrary, elderly people may have large medullary canal with thinner cortex.

The femur is covered by strong muscles and fasciae. Muscles are in three groups. Anterior group of muscles are exerting their actions upon hip and knee, causing flexion and extension respectively. Antero-medial group is for the adduction of thigh and posterior group brings the knee in flexion.

The chief function of the thigh is to keep the pelvis approximately horizontal.

Muscles of the thigh are richly supplied with arteries, the bone is also highly vascular. Femur receives its blood supply from the nutrient artery - the artery enters the bone and bifurcates, one for each end of the bone. Each one enters the metaphysis after dividing into sets of parallel vessels. Periosteum has got a very rich blood supply. These periosteal vessels also supply the bone. These vessels have got immense value for the union of the fractured bone.

In fracture of the shaft, shock is usually present due to profuse bleeding from the soft tissues and bone.

V. INDICATIONS FOR INTRAMEDULLARY NAILING IN FEMORAL SHAFT FRACTURES

Severe violence is the prime factor to cause fracture of the shaft of the femur at any site. It may be in upper, middle or lower third of the shaft. Men are mostly victims of this fracture. Because of the fact, they are more exposed to strenuous works. In our series 83% are male patients.

Now a days, intramedullary nailing has got wide field of indications. The indication is not limited within the line of demarcation. Previously, nobody could think of comminuted fracture that can be treated with intramedullary nailing. But it was shown by K.T. HERZOG and others that the comminuted fracture can be treated in a befitting manner with this nailing. At present it is practising abundantly.

The main fundamental idea is that, intramedullary nailing can be performed where stable osteosynthesis can be achieved. In Küntscher's version, "intramedullary nailing should be used in all cases in which a stable osteosynthesis can be achieved, providing that no contraindication is present".

Transverse, oblique and spiral fractures of the femoral shaft in adults are in clear indications of intramedullary nailing. But most suitable places in the upper and middle third of the shaft. In our view, fracture in the upper half of the lower third also gives excellent result with intramedullary nailing. Fresh closed fracture exhibits excellent result without any residual complication.

The so called double fractures, comminuted fracture,, can be treated with medullary nailing. But severely comminuted fracture always remain in vulnerable position for every possibility of rotation and shortening. Many surgeons view to apply additional support in comminuted fracture by circumferential wiring , but we are not in favour of this additional support, because, it will cause necrosis of the bone.

Intramedullary nailing, in compound fracture should be deferred until the wound is completely healed up.

Intramedullary nailing is also applicable to the shaft fracture of humerus, ulna, radius and tibia. Children are not suitable for intramedullary nailing, because of the danger of acute osteomyelitis. Operable pathological fracture of femoral shaft shows better result with intramedullary nailing than any other treatment. We operated two cases of shaft fracture of femur, one was a case of Paget's disease, another was fibrous dysplasia, both the cases have shown good result with intramedullary nailing.

Intramedullary nailing is the best possible treatment of malunion, delayed union and non union cases. Sometimes, the medullary canal in non union cases or in other cases may be wider; for stable osteosynthesis, double nails are to be inserted. In this respect, Küntscher's clover leaf nail serves the purpose best. John Charnley once faced the same difficulty with wider diameter of the canal, in a non union case and he impacted double Küntscher's clover leaf nail. Then he told, "this useful trick would seem to be another reason to support the superiority of the clover leaf pattern nail

over the solid type nail".

Due to wider girth of the canal of the lower third part of the shaft, nailing is not so suitable. As the nail can not be fitted snugly, so there is possibility of rotation of the distal fragment. But nailing can be done, being well supported by bone impaction in the canal of distal fragment. Supracondylar fracture of femur can be treated with dual medullary pinning.

Fig: 1. Knee arthrodesis by intramedullary nailing.

Arthrodesis of the knee joint can be performed by intramedullary nailing.(Figure 1). Generally it is done in painful arthritis deformans, tumours, in arthropathic conditions and in intractable arthralgia.

Subtrochanteric fracture of femur can also be treated with intramedullary nailing. Nail should be inserted through more medial to greater trochanter so as to avoid varus deformity.

Intramedullary nailing is also very useful in shortening and lengthening of the femur, considerable shortening of the femur due to deformity can be corrected by intramedullary nailing, and the remnant by shoes. But if the shortening is too much, beyond reach, then to emancipate this problem, the sound side is to be shortened for the symmetry

of the limbs. It is a controversial point, how much a limb can be shortened without having any side effect - the opinion varies. We have shortened about 8 cms. in one case, but, shortening should be considered according to height, weight and volume of the patient. The junction at the level of upper and middle third is selected deliberately for the shortening, just to get rid of isthmus.

The lengthening of the femur is gaining popularity now a days for cosmetic purpose.

VI. ASSESSMENT OF THE PATIENT AND OPERATIVE TECHNIQUE

A - ASSESSMENT OF THE PATIENT:

Patient with femoral shaft fracture should be examined thoroughly. If the patient is in shock, all possible measures are to be taken for resuscitation, till the patient is out of danger. It is wise, not to take any risk of performing intramedullary nailing in open fracture till the wound heals. Many surgeons are in favour of nailing in fresh open fracture of femoral shaft, after proper debridement. According to their opinion, the end result is more or less satisfactory.

For the intramedullary nailing, proper assessment of type of fracture, and site of fracture of the femur should be done correctly, so that nailing would not fail. If the patient has any other lesion, that should be consulted with the specialist of that branch. Above all, patient should be in good health, and has got no other contra-indication for the intramedullary nailing.

B - PRE-OPERATIVE MANAGEMENT:

As a routine method, we apply skin or skeletal traction to the injured limb, but mostly skeletal traction, just to overcome the muscular spasm and to bring the fractured ends in apposition, and alignment. This process helps the manipulation in future nailing. The length of time of traction is about 1-2 weeks.

Malunion cases are treated in two phases. In the first stage, osteotomy is done, followed by skeletal traction.

In the second stage, actual operation i.e. intramedullary nailing.

C - OPERATIVE TECHNIQUE:

We prefer open method to closed method for its justifiable advantages. Previously, we used diamond shaped nail, but due to having mechanical and other loop-holes, we prefer Küntscher's clover leaf nail to that one.

Patient should be placed in lateral position on the sound side. The injured extremity should be sterilized from mid leg to iliac crest or a bit up, followed by draping. (Fig. 2).

Fig:2. After sterilization and draping, the fractured limb is shown.

A longitudinal postero-lateral incision of about 6" has been given at the fracture site. After incised the fascia lata, bone can be approached by splitting the muscles or by following the intermuscular septum. (Fig. 3).

Fig: 3. Fascia lata is being incised and the muscle is exposed.

It is better to follow the latter one, retracting the soft tissues anteriorly. Now, the old haematoma, granulation tissues or fibrous tissues should be denuded. After exposing the fracture site, the fragments are exposed with little periosteal stripping. (Fig. 4)

Fig: 4. Fractured ends are being exposed.

Periosteal attachment is carefully preserved as far as practicable, just to avoid asepticnecrosis.

Now, the affected thigh is flexed on hip and adducted. The greater trochanter is being prominent, an incision of about 2" has been given over the tip of it,

Now,the greater trochanter and its small adjoining area is exposed. The area over the tip of the greater trochanter can also be exposed by an incision over the protruded end of the guide pin, when it will be introduced through the fractured end of the proximal fragment and will emerge out subcutaneously through the medial side of the greater trochanter.

The guide pin has got double edge facilities. First one, it acts as a guide for its successors, secondly, the length of the medullary canal can be determined. That length will be the length of the desired nail. This is done by introducing a guide pin into the distal fragment and into the proximal fragment through the respective fracture ends. The measurement in the distal fragment would be from the fractured end upto the upper end of the patella or at the level of adductor tubercle. In the proximal fragment upto the tip of the greater trochanter. The measurement should be confirmed by comparing with a second identical pin, placing outside the limb along with the inner one. Let the former one be 'A' and the latter one be 'B'. Now the total length of the canal is A+B.

The measurement of the nail can also be determined pre-operatively by scanogram (Fig. 5) or by measuring the unaffected limb with a tape from the tip of the greater trochanter upto upper border of the patella. From the x-ray of the sound side, the length, and the diameter of the medullary canal can be ascertained by scale or by ossimeter.

Fig.5: Scanogram of the normal limb.

About 2-3 cms. should be more in actual length of the nail than the length of the medullary canal. That portion will remain under the soft tissues and skin, above the tip of the greater trochanter. The guide pin has been introduced through the fractured end of the proximal fragment and it has emerged through the medial side of the greater trochanter. (Fig. 6).

Fig.6: The guide pin is being introduced through the fractured end of the proximal fragment.

The guide pin at the first instance can also be inserted through medial side of the greater trochanter into the proximal half.

After being emerged through the greater trochanter, the pin again should be pushed back upto the fractured end of the proximal half. Now the distal fragment is delivered and after manipulation the two ends have been brought in apposition, correcting the rotation, maintaining the anatomical plane. (Fig. 7). This apposition is retained with the help of bone holding forceps and by assistant. Next, the guide pin is driven through the distal fragement, the limit of insertion is determined with the help of second identical guide placing outside the limb alongwith the inner one.

Fig. 7: The guide pin has been driven through the distal fragment, after the apposition of two fractured ends.

Due to inequality of the medullary canal, during nailing, many forthcoming complications including obstruction may be implicated. To be assured against these hazards, intramedullary reamers for reaming the canal are used . Generally it is started with the smaller size of the reamer, it works inside the canal by gliding over the guide pin in situ (Fig. 8). The reamer need not to pass upto the lower

Fig. 8: The process of reaming is shown here.

lower half of the lower third of the femur, because of having wider diameter. When the resisting portions of the canal are cleared up, assuring the canal of known equal diameter throughout its length, reaming should be stopped. The reamer and the nail should be of same diameter.

This procedure of reaming can also be done through the fractured end, without prior reduction of the fracture. After this manoeuvre, the guide pin is passed through the fracture ends into the distal half, but,after the fracture is being reduced correctly, considering the anatomical alignment.

The correct desired nail should be selected in respect of length and diameter of the medullary canal. It will neither be smaller, nor bigger, and neither loose nor tight. The nail will fit snugly.

In every step of the operation surgeon will keep his vigilant eyes, not to entertain any mishap, exercise of great care can avert mishap. Before the insertion of the nail, the position of the limb with the position of the patella,

and the position of the reduced bone, also must be checked.

Now, the nail is inserted slowly over the guide pin. (Fig. 9). In driving the nail further, caution should

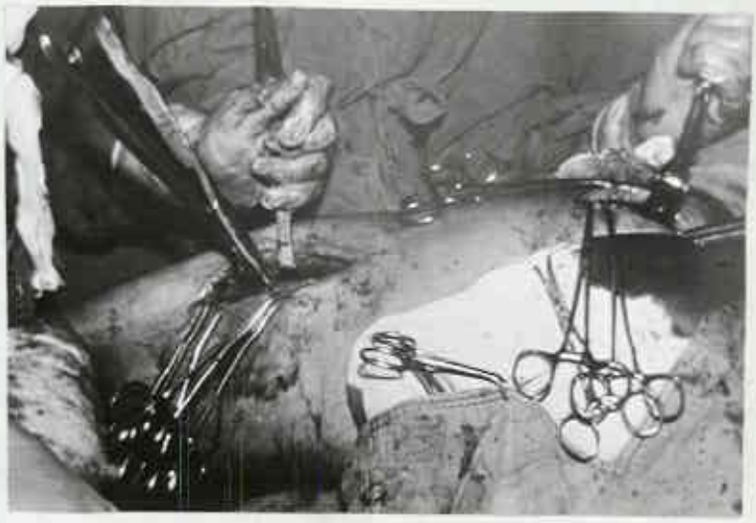

Fig.9: The Küntscher's clover leaf nail is being introduced into the medullary canal.

be taken. If the nail fails to progress by light hammering, pounding hammering should not be applied, may cause impingement into the cortex. If impingement occurs, the nail should be withdrawn, followed by re-insertion, by slightly rotating the nail. If it fails, it means nail is bigger, so smaller size nail can be tried or the canal can be enlarged by further reaming.

If the driving nail abruptly resists for further advancement or all on a sudden the friction force of the nail is diminished, it means,either the nail has stuck down in the cortex or the nail has intruded into the soft tissues. At once,the nail should be pulled out for re-insertion with great care. These sorts of catastrophes, now a days, specially in open method with reaming are very

rare and we did not face in our series.

The driving sound and the peculiar vibrating sensation of the nail during hammering will be the good guide for an experienced surgeon. Any change of sound of driving the nail and the sensation, will be apparently fore-warning to the surgeon against further impaction or intrusion.

Great care must be taken for the maintenance of reduction without any rotation. Otherwise, the nail may split the distal fragment or may impinge upon the cortex or may perforate the cortex due to rotation of the fragment. Maintenance of the reduction correctly, during nailing, is another secret of success of intramedullary nailing.

The last part of the nail is driven in by the tamping tool. (Fig. 10). About 2 cms. of the nail is kept

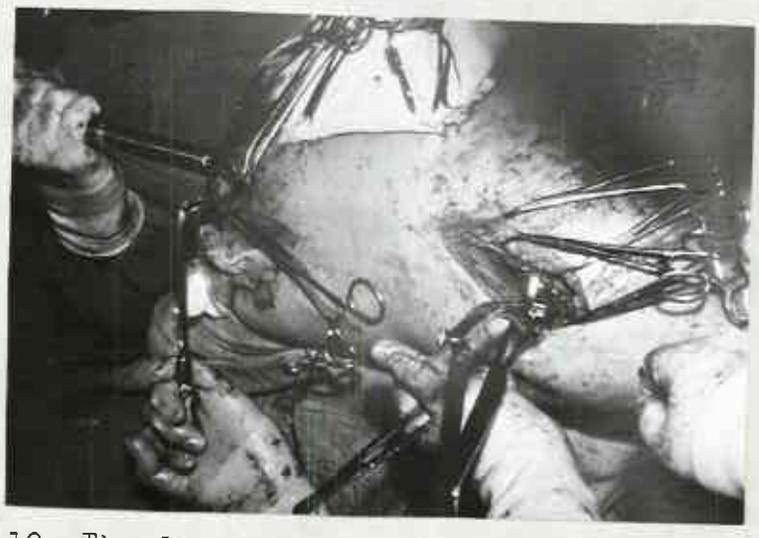

Fig. 10: The last part of the clover leaf nail is being inserted with the help of tamping tool.

above the greater trochanter, will remain under the sub-cutaneous tissues. This portion will act as a mediator for extraction. Now, wounds are closed in layers. (Fig. 11).

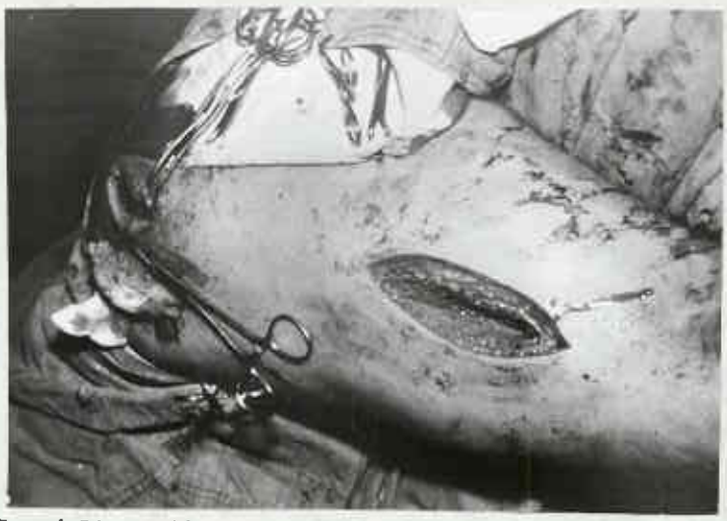

Fig.11: After the completion of intramedullary nailing the wound is being closed in layers.

It is wise to take x-ray of the limb for final checking of the nailing.

In cases of malunion, delayed and non union, fracture ends should be trimmed off, to freshen the ends, and nailing followed by bone graft at the site of fracture, gives satisfactory result. We do not advocate circumferential wiring in comminuted fracture, because, to avoid bone necrosis.

If pre-operative measures, estimation of length and diameter of the canal, with the correct selection of the nail, and all other correct procedures are strictly observed, the catastrophe has got no place in open method of intramedullary nailing.

D - POST-OPERATIVE MEASURES:

After the intramedullary nailing operation any external reinforcement is not required, whereas all other methods including plating will be supplemented by external immobilization.

Early movement of the limb and joints will bring back muscle tone, strength, and also the normal functions. This muscular exercise and early partial weight-bearing will make the osteosynthesis more stable and stimulate callus and union. After the operation, if the patient is confined to bed for weeks as post-operative extra-precautionary measure, then there is every chance of being restricted knee movement, muscular atrophy, and may cause distraction.

Too early full weight-bearing may also bring calamities, bending or breaking of the nail or propulsion of nail into the knee joint. So the patient will be warned from the very beginning, not to develop false feeling of confidence of the limb, - "pin euphoria", before the solid union occurs. Because, the limb may not sustain undue and unwarranted strain so early, resulting bending or breakage of the nail.

After the operation, below knee surface traction is applied for one week. Somebody prefers to apply compression bandage. Quadriceps exercise is encouraged from the next day of operation. After one week, patient is advised for active movement of the knee joint slowly. When the stitches are taken off, patient is allowed to walk with crutches, but, without any weight-bearing. As soon as callus begins to accumulate radiologically at the fracture site, patient is permitted to walk on crutches; gradually with partial weight-bearing under the guidance of a physiotherapist. Clinical and x-ray evidences of consolidation of callus attribute that the crutches are to be discarded, allowing the patient's walking with full weight-bearing.

VII. COMPLICATIONS AND DANGERS OF NAILING

Before the perfection of the nailing, many pitfalls and complications had been faced, but now a days perfection has overshadowed those drawbacks.

(i) Shock is not a problem only in intramedullary nailing, but also in other major operations, even it may ensue in other operations of femur as for, in osteotomy, plating and in insertion of the prosthesis in hip or knee joint..Correct pre-operative assessment of the patient; and the progress of anaesthesia, blood transfusion, and medicine, have diminished the incidence of shock. Neither we have faced any difficulty in nailing due to shock of the patient nor we have lost a single patient due to post-operative shock after intramedullary nailing.

(ii) Long nail may encroach upon the knee joint, and bigger size nail may impinge in the cortex or may split the bone. Smaller thin nail will allow the distal fragment to rotate outwardly, disturbing the osteosynthesis. If the cross section of the nail does not coincide with femur, the force will be exerted more aggresively upon the site of fracture causing bending or breakage of the nail, and deformity of the limb.

But, pre-operative assessment, reaming of the canal with correct selection of the nail and meticulous performance, all are almost equally responsible for the elimination of these complications and dangers. In our series we have not face such difficulty.

(iii) Fat embolism, as a complication of nailing was terror to the surgeons. Modifications of Küntscher's nail and open method have tremendously decreased this incidence. We have not encountered a single case of fat embolism in our nailing lists.

(iv) Thrombophlebitis, pulmonary and renal complications though are in the list of complications but we have not encountered in medullary nailing.

(v) An adventitious bursa may develop at the protruding end of the nail and sometimes an ossified cap may develop. We have got one case of ossified cap at the protruding end of the nail.

VIII. M A T E R I A L S

The records are proclaiming that from 1961-1969, eighty-nine adult cases of femoral shaft fractures of various types have been treated in HACETTEPE HOSPITAL. Thirty-four cases out of eighty-nine have been treated by intramedullary nailing; and the rest, by skeletal traction followed by plastering or by closed reduction followed by plastering, or by plating and screwing, reinforced by plaster of paris as an external support.

Among thirty-four cases, two cases are compound fractures, eight cases are comminuted, two cases spiral, five oblique and the rest are transverse fractures. Admission of all thirty-four cases, at this hospital, are not in the same day after injury. It can be studied from the following data - Table I.

T A B L E - I

ADMISSION TIME IN THE HOSPITAL AFTER INJURY	NO. OF CASES
Same day after injury	6 cases
One day after injury	5 cases
Within 2-7 days after injury	8 cases
Within 1-2 weeks after injury	2 cases
Within 2-3 weeks after injury	1 case
Within 1-2 months after injury	6 cases
Within 2-3 months after injury	2 cases
Within 5-6 months after injury	3 cases
Within 10-12 months after injury	1 case

All the above thirty-four cases were treated with intramedullary nailing, the profundity of advantages of nailing has been charted in Table II.

If the Table II is carefully studied, it is crystal clear that the end results of intramedullary nailing are excellent and unparalleled. Those patients got admitted themselves in the hospital without much delay and not associated with other injuries, have been discharged within a very short time after being treated with intramedullary nailing.

Following skeletal traction, open method of intramedullary nailing has been performed upon the patients. We are not in support of closed method. Recent cases enjoyed far better end result by intramedullary nailing than old cases. When patient comes late, it has been observed, generally, they come with deformity of the limb and joint.

However, in our series (in Table II), we have treated the following fresh femoral fracture cases, were not associated with any other inuries, by intramedullary nailing. These were eight recent transverse fractures (case No. 15, 18, 20, 25, 28, 29, 30 and 33), one spiral fracture (case No. 2), two cases of comminuted fractures (case No. 12 and 34), and one case of compound comminuted fracture (case No. 24). In all the above cases, the end results of intramedullary nailing are marvellous except that compound fracture case.

Besides that, the number of fresh fracture cases with other injuries were; six cases of transverse fracture

(case No. 1, 3, 6, 8, 9 and 31), one oblique fracture (case No. 19) and three comminuted fracture cases (case No. 7, 10 and 27).

Two cases of bilateral femoral shaft fractures (case No. 7 and 29) in our series have been treated by intramedullary nailing. Both the cases were fresh fractures One case (case No. 7) was bilateral comminuted fracture associated with other injuries, but the other one (case No. 29) was a case of bilateral transverse fracture, not accompanied by other injuries.

If we consider the Table II, then old cases without other injuries were, three transverse fractures (case No. 11, 13 and 16), one case of spiral fracture (case No. 26), two oblique fractures (case No. 14 and 23) and one was comminuted fracture (case No. 22).

But, old cases of fractures, associated with other injuries were five in number; one transverse case (case No. 21) two oblique fractures (case No. 4 and 5) , one case of comminuted fracture (case No. 17), and one was a case of compound fracture (case No. 32). All the old cases had deformities, following conservative treatment. In two cases, full length of the femur could not be achieved, and only two cases regained fully their lost functions of the knee joints.

IX. R E S U L T S

The successful result of femoral shaft fracture treatment in adults, depends upon many factors. The keystone, to solve all these factors is the type of treatment. No other method of treatment can stride over the femoral shaft fracture so nicely as the intramedullary nailing does. The results of intramedullary nailing of our series, given in Table II, as follows:- ++

Two patients (case No. 17 and 27) were treated with intramedullary nailing but they had patella fracture of the same side. In two, one (case No. 17) had mal-union of the femur and knee stiffness, who received conservative treatment in other hospital. Mal-union was corrected fully, following nailing; patellectomy had been done upon those two cases, after nailing. In both the cases, knee flexion movement are restricted following patellectomy, otherwise, union of the fractures are excellent without any other deformity.

Generally, when patients come late, it means that they are coming after being disappointed with other treatments and most of the patients present themselves with deformity. Such eleven patients (case No. 4, 5, 11, 13, 16, 17, 22, 23, 24, 26 and 32) came for further treatment, with mal-union, shortening, overriding or angulation. It was obvious, and also found that they came with appreciable knee stiffness. These are the end results of prolonged and improper immobilization and improper reduction, following conservative treatment.

++ see pp.38-40

Once stiffness is developed in the joint, it becomes a tooth and nail problem to irradicate the refractory stiffness. Usually, we treat these mal-union cases in two stages. In the first stage, osteotomy will be done, followed by skeletal traction for two to three weeks. In the second stage, intramedullary nailing will be performed. For the rehabilitation of the limb, knee joint, the patient should attend physiotherapy department. Of the eleven cases, two patients (case No. 4 and 11) regained normal functions of the knee joint, others improved a lot. but could not reach the target.

Only in two cases (No. 4 and 24), in our series, shortening of the limb could not be corrected fully. In one case (case No. 4), pre-nailing shortening was eight centimetres, after intramedullary nailing six and a half centimetres recovered. In another case (case No. 24), four centimetres came down to one centimetre. The latter one was a case of compound and severely comminuted fracture.

Sometimes, it is very difficult to correct all the shortening deformity fully, by the dint of merit of nailing. Fresh and recent the cases, best will be the end result of intramedullary nailing, least will be the sufferings of the patients.

In our series, one case (case No. 10), was a case of bilateral tibial fracturesalong with femoral shaft fracture. In other four femoral shaft fractures, two of them had same sided tibia fracture (case No. 6 and 31), and two had opposite sided tibia fractures (case No. 3 and 21). All the four cases were tackled with nailing; but tibia, conservatively. One case

of opposite sided tibia fracture (case No. 3) regained full range of movement of the knee joint, but other cases could not recuperate normal functions of the knee joint, for prolonged recumbency, due to concomitant fracture of tibia and other fracture injuries. The end result of intramedullary nailing was good in all the cases.

One case (case No. 14) of non-union with pseudo-arthrosis was interfered with intramedullary nailing, along with bone grafting at the fracture site. The end result is excellent. No other treatment can conquer this sort of deformity so magnificiently.

Two other cases (case No. 8, and 19), concomitantly had fracture of both ischium and pubis, and hip dislocation of the opposite side respectively. The case with dislocation of hip could not escape from knee complications but another case did. But the union of the femoral shaft fractures took place admirably excellent in both the cases; without any other untoward effect.

Three more cases (case No. 1, 7 and 9) were associated with injuries, all of them were rewarded with sound union of the fracture, by the outstanding performance of the intramedullary nailing. Two of them enjoyed full range of movement of the knee joint.

Two cases are not included in Table II. Both the cases were nailed by intramedullary nail in another hospital. One case had neck fracture of the femur and patella fracture of the same side. They did not interfere the neck fracture; their first endeavour was nailing of the shaft. When the patient

came under our care, the wound was highly infected accompanied by osteomyelitis of the femur. The nail was taken out and sequestrectomy was done. This was followed by Winnett Orr method. Now, there is coxa vara deformity, the limb is short by six centimetres with stiff knee.

Other one came to this hospital for further treatment, after one year of nailing. Angulation deformity developed with bending of the diamond shaped nail. The limb was short by four and a half centimetres, with coxa vara deformity of the contiguous hip. The nail was taken out and valgus osteotomy was done with restoration of two and a half centimetres length of the limb.

Considering the above two cases, we can confer that the merit of the case in all respects, should be meticulously scrutinized before nailing. The size, shape, length of the nail should be well computed considering the length and diameter of the medullary canal; operative and post-operative stages should be well regarded. Advice should be given also to the patients which are to be observed, otherwise, misfortune will come in disguise.

The photographic sequences of intramedullary nailing of Table II, are given on pages 41-48.

S

ection er I. ling	Bending or breaking of Nail	Knee joint function	Remarks
6	17	18	19
-	-	Full movement	Excellent
-	-	Full movement	Excellent
-	-	Full movement	Excellent
-	-	Full movement	Excellent
-	-	85° flexion movement	Excellent
-	-	25°flexion movement	Good
-	-	Flexion slightly restricted	Good
-	-	Flexion slightly restricted	Good
-	-	Normal movement	Excellent
-	-	Full movement	Excellent
-	-	80° Flexion movement	Good
-	-	Full movement	Excellent

nfection fter I. ailing.	Bending or breaking of Nail.	Knee joint function	Remarks
16	17	18	19
-	-	Full movement	Excellent
-	-	20° flexion movement	Good
-	-	Restricted movement	Good
-	-	Normal movement	Excellent
-	-	50° flexion movement	Good
-	-	70° flexion movement	Good
-	-	Full movement	Excellent
-	-	Flexion slightly restricted	Good
-	-	Full movement	Excellent
-	-	Flexion restricted	Good
-	-	90° flexion movement	Excellent
-	-	20° flexion movement	Good
-	-	15° flexion movement	Good
-	-	Normal movement	Excellent

Infection after I. Nailing.	Bending or breaking of Nail.	Knee joint function	Remarks
16	17	18	19
-	-	90° flexion movement	Excellent
-	-	75° flexion movement	Good
-	-	Full movement	Excellent
-	-	Normal movement	Excellent
-	-	Normal movement	Excellent
-	-	Full movement	Excellent
-	-	Flexion limited	Good
-	-	Very limited movement	Fair
-	-	Full movement	Excellent
-	-	Full movement	Excellent

Fig. 12

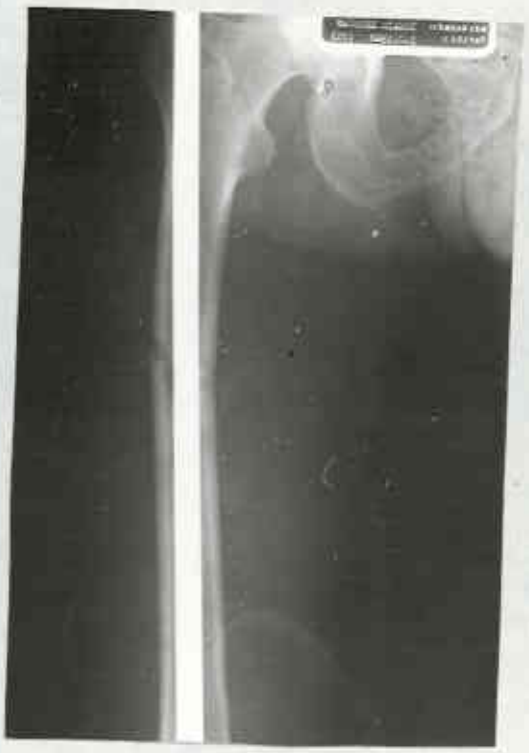

Fig.12-A:

Fig.12 & 12-A: A closed recent fracture.
(Case No. 1) 12-A:-After one month this x-ray is taken.
End result is excellent.

Fig.13

Fig.13-A:

Fig.13 & 13-A: Patient came with spiral fracture.
(Case No. 2) 13-A: Treated by nailing. Picture taken seven and
and half months after nailing. No deformity.

Fig.14

Fig.14-A:

Fig.14 & 14-A: This case was a malunited fracture.
(Case No. 5) 14-A: Nailing was performed. X-ray is taken after two months.

Fig. 15

Fig. 15-A:

Fig.15 & 15-A: Recent closed transverse fracture.
(Case No. 6) 15-A: Nail was inserted. Exuberent accumulation of callus. The film is taken after four months.

Fig. 16

Fig. 16-A:

Fig. 17

Fig. 17-A:

Fig.16 & 16-A and 17 & 17-A (Case No. 7) These two sets of photographs are of the same patient. This was a case of bilateral shaft fractures.

16-A & 17-A: Nailing was done. Union of the fractures excellent. No deformity.

Fig. 18

Fig. 18-A:

Fig.18 & 18-A: (Case No. 11)

This was a case of mal-union with shortening. After, nailing was performed.
18-A: This x-ray is taken 12 months after operation.

Fig.19

Fig. 19-A:

Fig.19 & 19-A: (Case No. 13)

A case of mal-union with shortening. Nailing has been done.
19-A: Film is taken three months after nailig. No residual deformity.

Fig. 20

Fig. 20-A:

Fig. 20 & 20-A: (Case No. 20) Fresh closed fracture.
20-a: X-ray, three days after nailing.

Fig. 21

Fig. 21-A:

Fig. 21 & 21-A: (Case No. 26) An old mal-united fracture with shortening.
21-A: Nailing has been done. Result is excellent.

Fig. 22

Fig. 22-A:

Fig. 22 & 22-A: (Case No. 27) Patient had closed comminuted fracture. 22-A: Nailing was performed. Union is excellent. Picture, after 12 months.

Fig. 23

Fig. 23-A:

Fig. 23 & 23-A: (Case No. 28) Closed transverse fracture. In the proximal fragment a crack was present. 23-A: Same patient. In view of preventing further splitting and for stability, a screw was fixed.

Fig. 24 (right side)

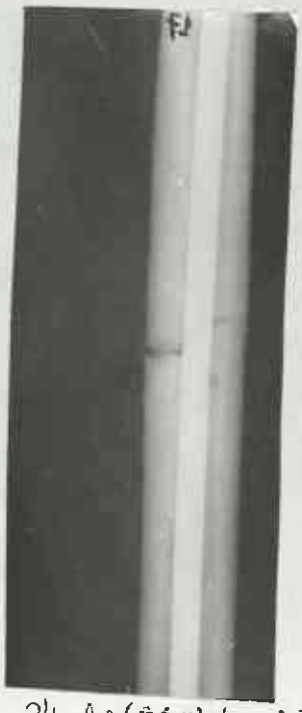

Fig. 24-A:(right side)

Fig. 25 (left side)

Fig. 25-A: (left side)

Fig. 24 & 24-A and 25-& 25-A (Case No. 29) This was a case of bilateral closed transverse fractures. Treated by nailing. 24-A & 25-A: Films are taken after being nailed.

Fig. 26

Fig. 26-A:

Fig.26 & 26-A: (Case No.30) The case was a fresh closed transverse fracture. Picture is taken after three weeks of nailing.
26-A: Same patient. X-ray is taken after a few months.

Fig. 27

Fig. 27-A:

Fig. 27 & 27-A: (Case No. 32) This was a compound fracture. Patient came with mal-union. Nailing was performed.
27-A: This film is taken for control after eight and a half months.

In this series, two cases of bilateral femoral shaft fractures were treated with intramedullary nailing. Each side of the bilateral case was operated in separate sitting.

Difference of opinions are existing among the surgeons concerning the exact time of nail extraction. It is very difficult to profess the exact time of callus formation following solidity of the callus of a specific patient. Average time of union can be drawn, but not the particular one. Healing time of fractures of two patients of same age will vary, depends upon many factors. Many are in favour of extracting the nail between four to eight months. But considering the reconciliation of clinical and radiological evidences, we, generally, extract the nail after one year.

T A B L E III

STUDY OF Hb% AND W.B.C. COUNT IN INTRAMEDULLARY NAILING

S.No.	Pre-operative Hb% in Gm.	Post-operative Hb% in Gm.	Pre-operative W.B.C. count per C.mm.	Post-operative W.B.C. count per C.mm.	Blood transfusion during operation.
1.	14.00	13.50	8200	8000	500 cc.
2.	15.95	14.85	6800	7200	950 cc.
3.	11.75	11.00	6000	6200	500 cc.
4.	12.64	11.25	8600	8400	-
5.	13.80	12.75	7000	6400	500 cc.
6.	12.50	11.00	5000	5100	-
7.	14.42	14.30	8600	8400	-

Table III continued.

8.	14.50	13.25	8600	7800	-
9.	14.50	13.00	6500	6800	-
10.	13.44	11.45	4600	7000	-
11.	10.15	9.96	7500	7400	350 cc.
12.	14.75	13.50	4600	4800	700 cc.
13.	13.60	11.44	4800	4000	300 cc.
14.	14.90	13.00	5200	5800	420 cc.
15.	12.20	11.80	5800	5400	-
16.	15.00	14.00	5600	5700	-
17.	10.40	8.60	8000	5500	-
18.	11.30	11.50	8000	8600	500 cc.
19.	10.35	10.00	6400	6000	800 cc.
20.	12.30	10.75	4200	4100	-
21.	13.05	11.25	5400.	5000	-
22.	12.75	13.05	5400	5600	800 cc.
23.	10.00	11.55	3000	5200	800 cc.
24.	12.55	12.00	8200	7800	400 cc.
25.	11.75	11.00	6600	6000	-
26.	14.30	13.30	5000	5000	-
27.	11.55	10.85	5200	5000	Given.
28.	14.55	14.00	4800	4500	350 cc.
29.	11.55	11.00	6400	6000	Given.
30.	14.00	13.50	8500	8000	850 cc.
31.	10.80	9.75	8400	8300	-

In the above table, the change of Hb% in intramedullary nailing has been focussed. The percentage of Hb% , before operation and a few days after the nailing has been outlined. Total count of W.B.C. also found out. It is evidently proved that the variations of Hb% and W.B.C. count are not

remarkable before and after nailing. So nailing has got no detrimental effect to Hb percentage..

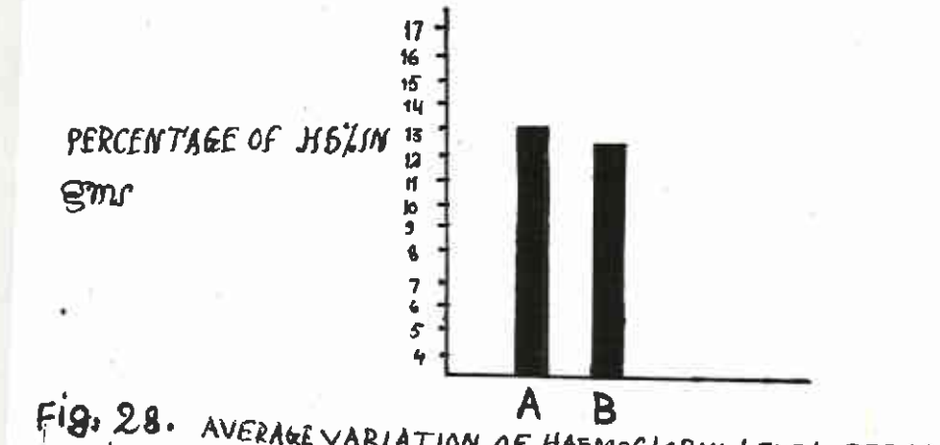

FIG. 28. AVERAGE VARIATION OF HAEMOGLOBIN LEVEL BEFORE AND AFTER INTRAMEDULLARY NAILING.

Fig. 28: A. Average Hb% level of the patients before intramedullary nailing.
B. Average Hb% level of those patients after intramedullary nailing.

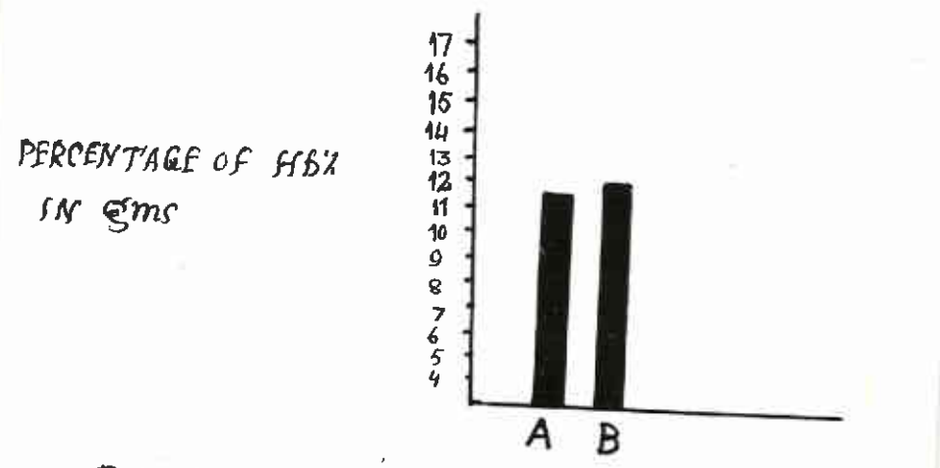

FIG. 29. VARIATION OF HAEMOGLOBIN LEVEL AFTER INTRAMEDULLARY NAILING.

Fig. 29: A. Level of Hb% of the patients before operation.
B. Hb% level of those patients after intramedullary nailing.

It is seen that in some patients Hb% have increased after nailing, following blood transfusion during operation.

T A B L E IV

STUDY OF Hb% AND W.B.C. COUNT IN OTHER ORTHOPAEDIC OPERATIONS

S.No.	Pre-operative Hb% in Gm.	Post-operative Hb% in Gm.	Pre-operative W.B.C. count per c.mm	Post-operative W.B.C. count per c.mm	Surgery done.	Blood transfusion during operation.
1.	10.50	10.00	5500	5100	Plating	Transfused
2.	12.30	11.50	11000	10800	Plating	-
3.	13.50	10.45	17800	10400	Plating	Transfused
4.	12.30	10.80	5800	8400	Open reduction	Transfused
5.	13.50	10.80	7000	6200	Osteotomy	Transfused
6.	12.30	10.00	5400	6300	Nailing	Transfused
7.	12.00	10.85	5200	4800	Nailing	-
8.	13.80	10.80	5400	4000	Plating	-
9.	14.70	14.05	8000	8000	Open reduction	-
10.	11.40	10.00	9600	8200	Arthrodesis	Transfused
11.	12.61	11.55	6400	6200	Nailing	-
12.	13.05	12.00	5600	5200	Nailing	-
13.	14.05	13.00	3800	3200	Nailing	Transfused
14.	15.40	12.30	7200	5600	Nailing	Transfused
15.	11.44	10.50	5400	5000	Plating	-
16.	12.75	11.75	7200	6900	Nailing	Transfused
17.	14.90	11.30	5800	5600	Nailing	-
18.	11.44	10.00	5400	5700	Hip prosthesis	Transfused
19.	14.00	13.31	5000	4400	Hip prosthesis	Transfused
20.	15.57	13.75	5600	5600	Hip prosthesis	Transfused
21.	10.05	9.05	8000	4000	Hip prosthesis	Transfused
22.	15.20	13.00	6000	6100	Nailing	Transfused
23.	12.20	11.00	4000	4600	Osteotomy	Transfused
24.	13.10	11.80	5600	5200	Hip prosthesis	Transfused

Table IV continued.

25.	10.00	8.15	4200	4800	Nailing	-
26.	13.47	11.35	4200	4000	Arthrodesis	Transfued
27.	15.24	13.00	4800	4000	Nailing	-
28.	14.42	11.30	5600	5400	Plating	-
29.	12.20	10.35	7400	6900	Open reduction	-
30.	15.57	11.74	4800	4800	Hip prosthesis	Transfused
31.	11.55	10.85	7400	6900	Plating	-

Study of Hb% level before, and after other internal fixations, osteotomy, arthrodesis, insertion of prosthesis, and other operations upon hip, thigh and arm of adult patients.

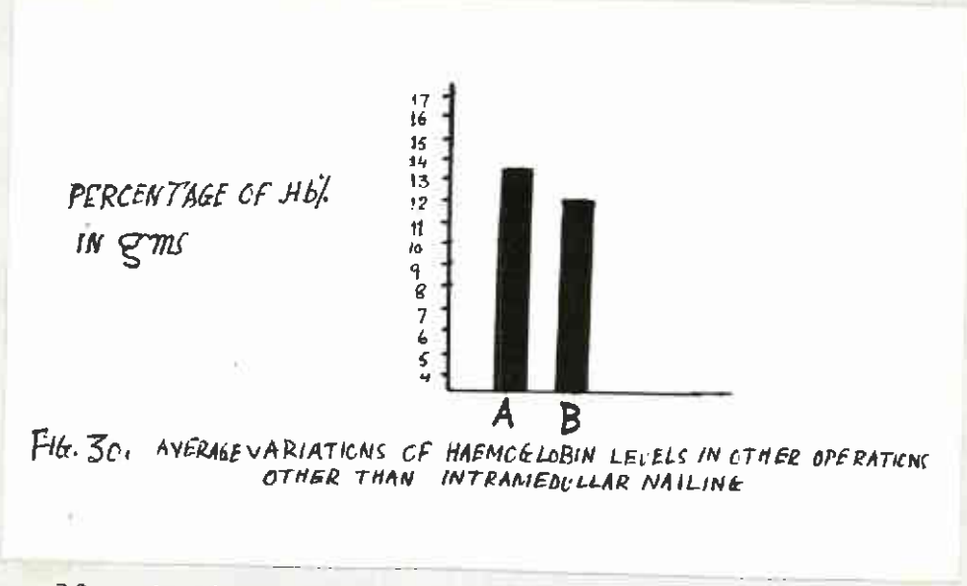

FIG. 30. AVERAGE VARIATIONS OF HAEMOGLOBIN LEVELS IN OTHER OPERATIONS OTHER THAN INTRAMEDULLAR NAILING

Fig. 30: A. Level of average Hb% of the patients before operations other than intramedullary nailing.
B. Average level of Hb% of those patients after operations as mentioned above, other than intramedullary nailing.

From the above graph (fig. 30), and data (table IV), we can infer that the difference of Hb% before and after other operations, is relatively more than intramedullary nailing as delineated in table III and graph (fig.28).

T A B L E V

RECORD OF DIURNAL VARIATION OF B.P. AND PULSE AND ALSO DURING INTRAMEDULLARY NAILING.

S.No.	Diurnal change of B.P.in mm Hg	Variation of B.P. during intramedullary nailing.	Diurnal change of pulse rate.	Variation of pulse rate during intramedullary nailing.
1.	110-140	130-100-140	85-110-80	100-90
2.	100-120	100-130	100-80	90-85
3.	120-130	120-110	75-85	80-65-75
4.	110-140	130-110	80-100	100-80-90
5.	100-130	115-110	85-105	100-90
6.	130-150	140-120	90-105	100-100
7.	120-140	120-100	85-120	80-90-100
8.	110-120	120-90-110	85-105-80	100-85
9.	110-120	110-100	80-105-75	80-70-80
10.	110-150	130-150-120	90-105-90	95-100-85
11.	110-130	130-110	90-100-95	110-90
12.	110-130	110-100	85-100-85	90-85-80
13.	110-120	110-100	90-95	90-95-85
14.	110-130	140-150-130	80-85	100-90
15.	110-120	120-110	80-100-80	85-70-95
16.	110-145	110-120-170	80-85-80	110-100-105
17.	110-140	125-150	100-80-105	120-100-110
18.	105-125	130-110-120	90-105-85	90-100-95
19.	110-140	130-100-120	80-85-80	100-90-80
20.	110-130	140-110-120	85-100-75	90-85-80
21.	130-140	130-140	85-95	80-60-75
22.	125-130-140	130-110-130	90-100-90	90-85-90
23.	120-140	140-130-145	85-100-85	100-85-90
24.	120-140	120-130-120	85-100-80	90-100

Table V continued.

25.	110-120	120-110	85-75	90-85
26.	120-130	140-150-140	80-100-85	85-75
27.	120-140	120-130-120	95-100-90	90-80
28.	110-125	135-120-110	80-85-80	95-75
29.	110-120	120-90-120	90-100-80	100-80-110
30.	120-140	140-130-140	85-100-85	100-85-90
31.	105-120	100-120.	100-80-105	80-90

Here the study of variationsof blood pressure and pulse rate of the patients. These are maximum diurnal variations and during actual intramedullary nailing operations. The fluctuation of B.P. and pulse during nailing are not at all contradictory points for which nailing should be in abeyance.

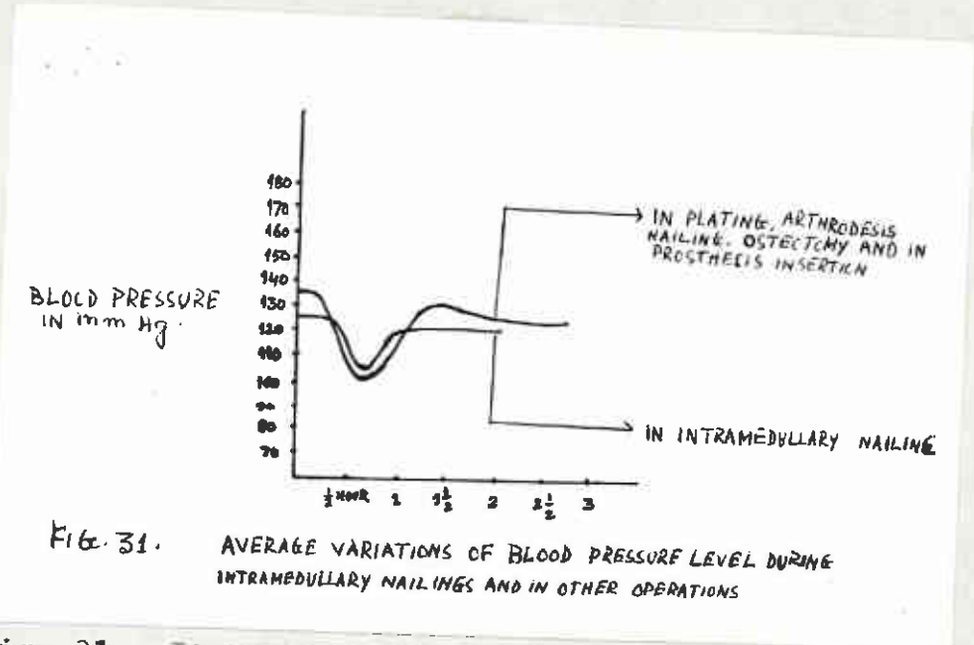

Fig. 31. AVERAGE VARIATIONS OF BLOOD PRESSURE LEVEL DURING INTRAMEDULLARY NAILINGS AND IN OTHER OPERATIONS

Fig. 31. It is shown in graph the fluctuation of blood pressure during intramedullary nailing and in plating, nailing open reduction, erthrodesis, and in prosthetic insertion etc. Average variation of B.P. in intramedullary nailing is 20 mm Hg and in others, it is 36 mm Hg.

T A B L E VI

RESULTS OF FEMORAL SHAFT FRACTURES WITH CONSERVATIVE TREATMENT

S. No.	Age.	Type	Location.	Method	Mal-union.	Shorte-ning.	Angu-lation.	Knee function.
1.	27	Simple	Middle	Skeletal traction and plaster.	-	-	-	Flexion deformity.
2.	23	Simple	Middle	Skeletal traction and plaster.	-	-	-	Restricted flexion.
3.	28	Simple	Middle	Skeletal traction and plaster.	-	-	-	Restricted movement.
4.	34	Simple	Lower	Closed reduction and plaster.	+	+	+	Restricted flexion.
5.	32	Simple	Upper	Closed reduction and plaster.	-	-	-	Restricted flexion.
6.	64	Simple	Lower	Skeletal traction and plaster.	-	-	-	95° flexion present.
7.	31	Comminuted	Upper	Skeletal traction and plaster.	-	-	-	Restricted flexion.
8.	16	Simple	Middle	Skeletal traction and plaster.	+	+	+	Restricted flexion.
9.	65	Simple	Middle	Skeletal traction and plaster.	+	+	+	Restricted.
10.	39	Simple	Lower	Skeletal traction and plaster.	-	-	-	15° flexion present.

Table VI continued.

11.	23	Simple	Middle	Skeletal traction and plaster.	-	-	-	15° flexion present.
12.	16	Simple	Middle	Skeletal traction and plaster.	+	+	-	Restricted movement.
13.	33	Simple	Lower	Skeletal traction and plaster.	+	+	-	Restricted movement.
14.	25	Com-pound	Middle	Skeletal traction and plaster.	-	-	-	20° flexion present.

It is understood from the above data that complications have got a very good place in the conservative treatment of femoral shaft fracturesin adults. Eleven cases of mal-union and one case of non-union as given in Table II are not included in the above Table. These are the symbolic recurring interpretations of conservative treatment.

T A B L E VII

IMPAIRED KNEE FUNCTIONS NOT IMPROVED FULLY FOLLOWING SURGERY

S. No.	Age.	Type.	Location	Complication.	Surgery done after complication
1.	51	Simple	Lower	Mal-union	Osteotomy and plating
2.	38	Simple	Lower	Mal-union	Osteotomy and plating
3.	23	Com-pound	Lower	Infected	Plating
4.	50	Simple	Upper	Mal-union	Osteotomy and plating
5.	50	Simple	Upper	Mal-union	Osteotomy and plating
6.	33	Simple	Lower	Mal-union	Osteotomy and plating
7.	45	Simple	Lower	Mal-union	Osteotomy and plating
8.	65	Com-pound	Lower	Infected	Plating
9.	47	Simple	Middle	Infected	Sequestrectomy followed by plaster
10.	16	Simple	Lower	Infected	Plating

In this data, it is only shown that the complications following skeletal traction in collaboration with plaster of paris or with other conservative methods, again pursued by other surgical interventions, but, none of the patients could regain normal knee functions.

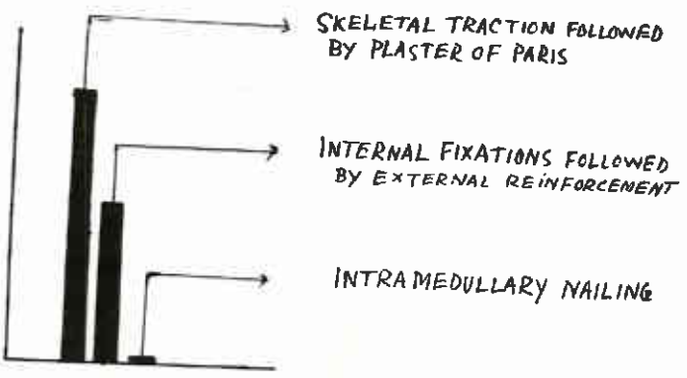

Fig. 32. COMPARATIVE GRAPH OF RECUMBENCY PERIOD IN DIFFERENT METHODS OF TREATMENT IN ADULT, IN FEMORAL SHAFT FRACTURE

Fig. 32:

Comparative graph of recumbent period of different methods of treatment in adults of femoral shaft fractures.

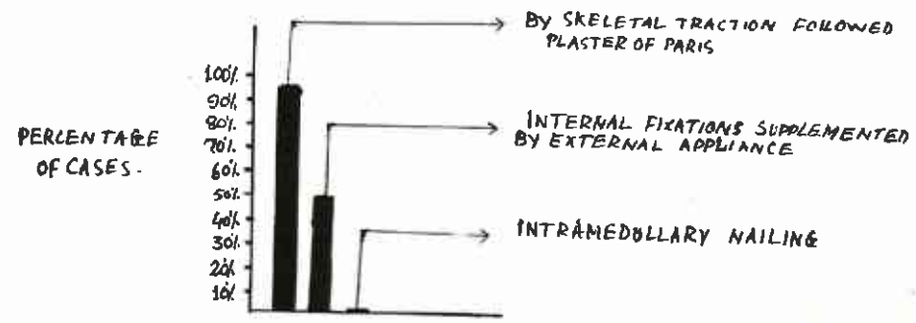

Fig. 33. COMPARATIVE STUDY OF RETARDATION OF KNEE FUNCTION OF ADULTS IN DIFFERENT METHODS OF TREATMENT IN FEMORAL SHAFT FRACTURE

Fig. 33:

Comparative study of retardation of knee functions of adults in different methods of treatment of femoral shaft fractures.

The recumbent period of intramedullary nailing is very negligible and the occurence of knee stiffness after intramedullary nailing is almost nil, provided no other concomitant fractures or injuries are present. If so, patient will have to stay in bed for a long time, and early movement of the limb is not possible.

X. DISCUSSION AND CONCLUSION

D I S C U S S I O N S

A - INTRODUCTION

From the statistical analysis of treatments of femoral shaft fracture in adults, in the previous chapter, it is proved that intramedullary nailing has got immense command and supremacy over femoral shaft fractures, also on deformities caused by other managements and factors.

II. Union is not the only criterion of successful fracture treatment, but to restore the anatomical contour of the limb and normal functions of the joint. Intramedullary nailing is the only method by which perfect and effectual union of the femoral shaft fracture can be achieved with reconciliation of above mentioned factors, provided the integrities are not badly disturbed previously by other managements. The success of other methods are not commensurate with the success of intramedullary nailing.

B - MATERIALS

During the last nine years, from 1961-69, eighty-nine adults patients of femoral shaft fractures were admitted into this hospital for treatment. Thirty-four cases out of eighty-nine, were treated with intramedullary nailing. All the cases were not fresh or recent, and the time of admission into the hospital, after injury, has been charted in Table I. Rest fifty-five cases had been tried with skeletal fraction incorporated with plaster or skin traction followed by plaster or closed reduction followed by plastering, or by

plating. But, here also, every patient could not make convenient to be admitted in the hospital on the same day, after injury.

II. Reasons are, firstly, all standard hospitals are highly charged, so all the patients could not afford the hospital treatment. The economic condition impelled many patients to a less experienced hand for treatment. Most of the cases come back with deformity. After being disappointed some of the patients again come to the specialist in a hospital for further treatment. But it becomes a burden for them to bear the hospital expenditures.

Secondly, number of beds in the hospital can not meet up the demands of patients, as number of well equipped hospitals are less. So thedeserved patients could not find better hospital facilities at their prime hours of necessity. Among fifty-five cases, only eight cases got the chance to be admitted in this hospital on the same day after injury. Due to shortage of beds, twenty-one cases got admission within one week; three cases within one to two weeks; eight cases within two to three weeks; two cases within one to two months; eight cases in between two to three months after injury; two cases in between three tofour months and last three within six months to one year following injury. This late coming of the patients are due to shortage of accommodation in the hospital, and on account of financial condition of the patients and to some extent due to callousness of the patient and negligence of the patients' relatives.

(iii) In Turkey, pattern of road accidents out-numbered other types of accidents. According to our statistics about 80% cases were injured due to traffic accidents. In eighty-nine cases 83% are male patients, as they are exposed to strenuous and multifarious works.

(iv) Due to rush , the patients, in some occasions, are discharged earlier than scheduled time with proper directions and advices. But many patients do not comply with the doctor's advice, as they are non co-operative patients and do not turn up in time for control. It is also found that if the post-operative progress of treatment goes steadily with benign effect many patients do not turn up for final check up. We requested patients of our series, through letters to come for final check up, but only 58.8% of patients came for that.

(v) Thirty-four cases out of eighty-nine cases thrived with intramedullary nailing, tabulated in table II. All the fractures were not recent one. In our series twelve cases (case No.4, 5, 11, 13, 14, 16, 17, 22, 23, 24, 26 and 32) out of thirty-four cases came with deformity for further treatment. Eleven cases were associated with other injuries (case No.1, 3, 6, 7, 8, 9, 10, 19,21,27 & 31), and eleven cases were with recent fractures without any other injuries (case No. 2, 12, 15, 18, 20, 25, 28, 29, 30, 33 and 34).

In Table VI, five cases (case No. 4, 8, 9, 12 and 13) were involved in deformities and complications, by skeletal traction followed by plastering or with other conservative

methods as mentioned, also evoked restricted knee movements in all the cases.

In Table VII, ten cases associated with complications, again tried with other surgery but normal knee functions could not be revived in any one of the cases.

In Table VI & VII, unfortunately all other cases could not be included as history sheets are not in order - incomplete.

(vi) It is reckoned that in our series average period of staying of our patients with femoral shaft fractures, not related with other injury, is only 16.5 days in the hospital after intramedullary nailing. We could discharge the patient more earlier after nailing but generally patients are being taught how to walk with crutches after the removal of stitches. After that patients are being discharged from the hospital.

The average period of hospitalization of the patient of recent fracture associated with other injuries, after nailing, is 18.6 days, and those of old cases with deformity is 22 days (according to Table II). The latter group is the subject to operation in two stages. In the first phase we have done osteotomy, followed by skeletal traction. In the second phase, the main operation - namely intramedullary nailing. The duration of traction is about two to three weeks. This is our regular episode that primarily we apply skeletal traction to the injured limb of femoral shaft fracture. In uncomplicated cases, the

traction period is 1-2 weeks. The object of this traction, the prelude is just to over come the muscular spasm and to bring the fractured ends in alignment and more or less in apposition. This transitory, precedent traction has got immense value, in performing the intramedullary nailing. This combined method, is another cause of successful stable osteosynthesis following perfect union in our series.

On the background of type of fracture of the femoral shaft, deformity of the limb and severity of other injuries, patient passed more number of days in the hospital before intramedullary nailing (Table II). In many occasions patients are to wait on chance for operation due to heavy pressure of other cases, and the output of operations can not cover up the demand, due to inconvenience of operation theatre. So, in consequence of these conditions, many occasions, patients are to stay few more days in the hospital in addition to pre-operative preparatory days.

C - METHOD

The indubitable exactitude of open method of intramedullary nailing has led us to adopt open method in the treatment of femoral shaft fractures. In our series, we have performed intramedullary nailing by open method and all the thirty-four cases have given excellent results without any catastrophe. We are not in favour of closed method for the following reasons:-

(i) Many surgeons are in favour of closed method, just to avoid infection. But it has been found that infection has got no respect even for closed method. During manoeuvre of closed method, every possibility due to repeated effort in passing the nail through distal fragment will injure the soft tissues,and the ends of the fractured bone, causing much bleeding. Haematoma forms, this may be the nidus for infection. Another point is that repeated trial by different size of nails may call for infection. Exact stable osteosynthesis is better in open method, this exact osteosynthesis also has reduced the chance of infection.

(ii) The closed method is a blind method, the surety of success hangs in the balance of uncertainty. The intrusion of nail through distal fragment is quite difficult and more it is dangerous, the nail may fail to enter into the medullary canal, this mishap may even count for life of the patient, by rupturing the popliteal artery. This failing, sometime may injure the seiatic nerve.

(iii) Closed method always consumes much time. More consumption of time in operation and repeated trial for reduction may cast the patient into deepshock. Reaming in closed method is another fatal approach and very cumbersome. In this method, surgeons require much dexterity, still, surgeons depend on x-ray or image amplifier for the perfection of the operation. This is a painstaking procedure and this additional help

may call for radiant dermatitis of the patient, and also may encumber the operation by infection as every time the x-ray machine is coming in close contact with the patient.

(iv) In closed method, there is every possibility of interposing of soft tissues causing non or delayed union. Repeated efforts in closed method for alignment and reduction produced too much trauma at the fracture site, may cause non or delayed union.

(v) Incidence of fat embolism had has more in closed method but it is reduced from the epoch of open method.

(vi) Perfect reposition of fracture does not implicate articular surfaces of the joint. This is very important in case of weight bearing joint. If this requisite condition is not fulfilled, osteo-arthritis is inevitable in future. It can be asserted that no method is equal to open method in accurate reduction.

(vii) Closed method is neither suitable for all types of shaft fractures of femur nor for non-union, delayed and mal-union of fractures. On the other hand open method is the only compatible method for those above mentioned fracture problems.

(viii) Intramedullary nailing in open method is done under the direct vision of the surgeon and he can proceed in every step of the operation in proper

perspective. Time consumption is more predictable and obviously less time consuming without any detrimental effect to the patient. Additional help of x-ray is not necessary during operation, but, necessary for the closed one at the very outset. That is another way to avoid infection and radiant effect to the patient. Open method causes less tissue damage. It is easier, precise, less hazardous, effectual, with less effort and manipulation. The consecutions of open method are uneventful and very satisfactory.

D - TYPE OF NAIL

The question also stands which type of nail is to be used in femoral shaft fracture and why ? In solid type, the best one is Hansen Street diamond shaped nail. Previously, we used diamond shaped nail, but it could not bring forth convincing results as clover leaf nail does, so since 1968 we are using Küntscher's clover leaf nail.

(ii) The diamond shaped nail is compact and heavy. During stress and strain this nail bends easily. The compactness, heaviness and shape of the nail have depreciated its qualities.

(iii) By the dint of its shape, it enters into the canal by cutting its own channel. The shape of the nail does not allow the nail to fit snugly in the medullary canal and there is less contact with the bone. As the cross section of the nail does not coincide with the femur, so the force will be exerted more aggresively

at the fracture site, resulting bending or breaking of the nail.

(iv) Due to heaviness and less contact with the bone, and not being snugly fitted, sometime this nail migrates to the knee joint, destroying the integrity of the joint.

(v) The protruding upper end of the diamond shaped nail is a pointed screw-nail. Pointed and sharp edges irritate vigorously the surrounding soft tissues, resulting adventitious bursa, more at the end of this nail. Sometime this bursa may be calcified. In our series, we have faced this sort of ossified cap in one case (Fig. 34) of nailing with diamond shaped nail.

Fig. 34. It is showing an ossified cap at the protruding end of a diamond shaped nail.

(vi) To the contrary, Kuntscher's hollow nail, remarkably the clover leaf nail is the most suitable nail for intramedullary nailing of femoral shaft fracture. The reason is that clover leaf is stronger, compressible, resilient and also the shape is advantageous to nailing. Due to its configuration, it comes in contact more with the bone, inside the medullary canal.

(vii) The configuration, compressibility and the resilience of the clover leaf nail help the nail to be adapted in a betterway to the irregularities of the cortex and evenly throughout the canal. Due to above compliments the clover leaf nail is most suitable for insertion along the normal anteriorly curved femur, This nail will not rotate during insertion, but will be set snugly in the canal, and it is also stable against rotatory strain after insertion.

(viii) Another striking point is that, by virtue of its configuration, resilience, and well concidence of cross section with that of canal, it can resist stress and strain. So, the percentage of bending of clover leaf nail is the least than other nails.

(ix) Stable osteosynthesis of femoral shaft fracture with wide medullary canal, mostly in non-union cases, can only be achieved by stacking two clover leaf nails in the canal. Only clover leaf nail possesses this accommodative quality. This is another point of supremacy of clover leaf nail over the solid type nail.

E - EFFECT OF INTRAMEDULLARY NAILING ON HB% LEVEL

This is also a matter of discussion whether intramedullary nailing has got any effect upon Haemoglobin content of the blood or not ? It generally comes in a mind that nailing may tarnish the Hb% of the patient as the bone marrow of the femur is disturbed. For the lucidity of the problem, it has been carefully studied (Table III) upon the operated patients, and the conclusion is that intramedullary nailing has got no appreciable consequence on Hb% of the patients. Moreover, in our series about 55% cases needed blood transfusion during nailing. Apparently, all the cases of intramedullary nailing do not require blood transfusion.

(ii) From the data (Table IV), it is seen that haemoglobin percentage fluctuates more (Fig.30) in other operations of femur and hip. In these miscellaneous operations 58% of cases demanded for blood transfusion. It is also observed that in few operations, blood transfusion is the part and parcel of the operation as a routine phenomenon.

F - EFFECT OF INTRAMEDULLARY NAILING ON B.P. AND PULSE RATE

It is also remarked that the fall of blood pressure during intramedullary nailing is quite high. But we have studied the blood pressure variations during nailing on our patients and it is recorded (Table V) that average compensatory fall of blood pressure is only 20 mm. Hg. This can also be brought forward from the

data that during osteotomy, internal fixation of the femur and in hip prosthesis insertion, average fall of blood pressure is 36 mm. Hg. more than that of intramedullary nailing (Fig. 31).

From the data (Table V), it can also be mentioned that average fall of pulse rate is 10 beats in intramedullary nailing. In other operations as mentioned above it is 16 beats.

G - ROLE OF SHOCK IN INTRAMEDULLARY NAILING

Many surgeons raised hue and cry in apprehension of shock of the patients in intramedullary nailing of the femoral shaft fracture. So, they are not in favour of nailing of the femoral shaft fracture. But, shock has got no predilection for intramedullary nailing only. Any patient may be subjected to shock in any operation, if the operation is time consuming, and if there is profuse haemorrhage. But, virtually, intramedullary nailing is less time consuming, and haemorrhage is not appreciable.

(ii) In other operations of the thigh, in osteotomy, internal fixations of the thigh and in prosthesis insertion of the hip, patients are in more vulnerable position due to time consumption or haemmorhage, and may be involved in shock. But in this scientific age, medical science is highly advanced, including anesthesiology and blood transfusion; so shock has got little place in operations. If shock ensues, it can be easily combated. In our series, none of the patient died of

shock nor had gone under shock during intramedullary nailing.

H - INCIDENCE OF FAT EMBOLISM IN INTRAMEDULLARY NILING

Fat embolism is one of the rarest complications of intramedullary nailing of femoral shaft fracture. It was a panic to the surgeons in intramedullary nailing. But it is very difficult to decide whether fat embolism is due to nailing or due to fracture, as only fracture is not exempted from the occurence of fat embolism.

(ii) However, it has been deduced that solid round shaped or diamond shaped nails are more vulnerable to this complication. Not only the nail, but the closed method is also partially responsible. Because of the fact, that due to compactness of the nail the intramedullary pressure can not find any way to escape, so the pressure inside the canal shoots up and up. At the same time the bone marrow can not flow through the nail, so, it is imprisoned in that inauspicious high pressure. This entangled fat of bone marrow may escape through vessels as embolus, causing catastrophe to the patient. The exact mechanism of fat embolism in this respect is still unknown.

(iii) The incidence of fat embolism has come down to the base line with the advent of Küntscher's hollow nail. The nail is hollow, so the pressure can be released and bone marrow will escape from pressure. The nail will act as a safety valve to release the intra-medullary pressure. Open method technique also acts as

an additional safety valve in this connection. So, there is least chance of fat embolism. None of our patients was a victim of fat embolism.

I - EFFECTS OF INTRAMEDULLARY NAILING AND OTHER METHODS ON KNEE FUNCTIONS

Knee stiffness is another traditional complication in adults following femoral shaft fracture. But apparently, development of restricted movement of knee depends upon the method of treatment. It is shown in Table II, Table VI & VII. Knee stiffness in adults following fracture, due to prolonged immobilization of the limb, could not be corrected fully all the time, even after physiotherapy treatment. Because of the fact, extra-articular and intra-articular adhesion play important roles in ultimate return of functions of the joint. Once, intra-articular adhesion is established, it is very difficult to irradicate completely, so the difficult to regain full range of movement of the knee joint.

(ii) In immobilized knee joint of adults, the articular cartilage can not get nourishment properly. During movements of the joint, there will be change of hydrostatic pressure inside joint space due to alternate compression and relaxation of the joint articular surfaces and thus facilitates the nourshing fluid to enter into the articular cartilage. Due to immobilization, articular cartilage can not have its requisite nourishment. The articular cartilage becomes sick, and gradually gets atrophy, inviting the fibrous tissues to be accumulated.

Once fibrous tissues, the intruders come, it is very difficult to eliminate them, causing stiffness of the knee joint. So, the joint can not exhibit its normal functions. This stiffness is also exaggerated by the extra-articular adhesion. But, extra-articular adhesion is vincible.

(iii) On the other hand, in children, immobilization can not affect the joint so much. Because articular cartilages of children are getting nourishment by two routes, and at the same time the rate of imbibition of fluid into the articular cartilage is good. One route is through the joint space and another one through subchondral bone. So during immobilization, if the supply through joint space is cut off, the nourishment of the cartilage is not hampered. It gets supply through subchondral route, so the articular cartilage does not suffer so much. When the external support for immobilization is taken off, gradually children regain full length of movements of the knee joint.

(iv) This is one of the crucial points for which the treatment of femoral shaft fracture in adults, with conservative method and internal fixation where prolonged immobilization are needed, are not at all suitable and advisable. Whereas, early movement of the knee joint after intramedullary nailing promotes full range of movement of the joint.

(v) In our series, results of intramedullary nailing are peerless. It is closely observed that recent

the fracture, not associated with any other injuries, unique is the result preserving the normal knee functions. It is also observed that, if the type of concomitant injury does not compel the patient to stay in bed for a long time and if the patient can move the nailed lower limb earlier actively, in those cases also, normal knee functions will be established.

Eleven cases recent and without any other injuries were intervened by intramedullary nailing and the culmination of success has been achieved by this treatment.

Other eleven cases were related with other fractures and injuries, the union of fractures of all the cases following nailing are praiseworthy, but only four cases subjugated the stiffness of the knee joints. Other cases could not, because, due to other injuries or fractures. Patients passed prolonged period in recumbency, that affected the normal knee function as early movement of the limb was not possible.

Rest were old complicated cases and all the cases had restricted knee movements. Consummation of length of the limb could not be achieved in two cases. In one case, shortening was too much, eight centimetres; in other one it was four centimetres, but the latter one was so badly mal-united case following compound comminuted fracture that in any way full length could not be achieved. Only in two cases, knee joints regained normal functions,

other cases had indelible restricted movements - beyond threshold level.

S U M M A R Y

In our series, thirty-four cases of femoral shaft fracture have been treated with intramedullary nailing, and union of the fracture is concerned, it is un-paralleled in all the cases.

(ii) It is also deduced that recent closed fracture, not entangled with any other injuries, has displayed splendid end results by intramedullary nailing with the preservation of normal knee functions.

(iii) If additional injury of the body does not stand on the way of knee movement and if the patient can move the limb earlier after intramedullary nailing, then, stiffness has got no place.

(iv) Intramedullary nailing has rendered excellent service to complicated cases of mal-union and non-union. All these deformities do not yield so easily to any other method. In our series, 16.6% cases with deformity regained normal knee functions after nailing. But once the integrity of an adult knee is disturbed, the result of restoration of normal knee function, in most of the cases will be disappointing.

(v) Open method has got tremendous advantages, and we have not faced any difficulty in our series with this method. Over and above, end results of union are

excellent. It is also experienced that Küntscher's clover leaf nail is the best one for intramedullary nailing of femoral shaft fracture, and evidently osteosynthesis will be stable, and initiates early callus formation, so patient can apply weight bearing earlier.

(vi) It is studied, in our series, that intramedullary nailing has got no such significant prejudicial effect upon Hb% . It is discussed in the light of our observation that during intramedullary nailing, the average fall of blood pressure also, is not at all remarkable.

C O N C L U S I O N

Femur is the weight bearing bone, so to treat the fracture of the femoral shaft in adults, perfectly, is not an easy task. Problems of this fracture can not be solved so easily by conservative method, rather it entangles complications.Even internal fixations except intramedullary nailing are not congenial to femoral shaft fracture, because of so many drawbacks.

Considering all the merits and demerits of the methods of treatment, it is concluded, and the infallible truism is that, intramedullary nailing is the treatment of choice of femoral shaft fractures in adults.

XI. B I B L I O G R A P H Y

1. APLEY, A.G.: A system of orthopaedics and fracture, . . . edition. 3:488, 1968, Butterworths & Co. (Publishers) Ltd.,England.

2. ARMSTRONG, J.R.: Treatment of fractures of third of femur shaft, lancet. May: 957, 1940.

3. BABCOCK's.: Principle and practice of surgery, edition. 2: 332, 1954, Lea & Febiger, Philadelphia.

4. BAILEY, H.: Demonstration of physical sign in clinical surgery, edition. 13: 712, 1960, John Wright and Sons Limited, Bristol.

5. BAILEY., and LOVE.: Short practice of surgery, edition.14:218, 1968, H.K. Lewis & Co. Ltd., London.

6. BÖHLER, J.: Results in intramedullary nailing of ninety-five fresh fractures of the femur, J. Bone & Joint Surgery. 33-A: 670, 1951.

7. BÖHLER, J., and BÖHLER, L.: Küntscher medullary nailing, J. Bone and Joint Surgery. 34:693, 1953.

8. BÖHLER, L.: The treatment of fracture, English edition 5, (based on the thirteenth German edition), Vol. 2, 1957, Grune & Startton, New York & London.

9. BÖHLER, L., and BÖHLER, J.: Küntscher medullary nailing, J. Bone and Joint Surgery. 31-A: 295, 1949.

10. BONNIN, J.G.: A textbook of fractures and related injuries, edition.1:495, 1957, Grune & Stratton Inc., New York.

11. BRAV, E.A.: Intramedullary nailing, Surgery. 34: 693, 1953.

12. BRAV, E.A., and JEFFRESS, V.H.: Fractures of femoral shaft, clinical comparison of treatment by traction, suspension and intramedullary nailing, Am. J. Surgery. 84: 16, 1952.

13. CAMPBELL'S.: Operative orthopaedics, edition 4, Vol.1:435, 1963, The C.V. Mosby Company, Saintlouis.

14. CHARNLEY, J.: Correspondence regarding intramedullary nailing of fractures, J. Bone and Joint Surgery. 34-B: 162, 1952.

15. CHARNLEY, J.: The closed treatment of common fractures, edition.3, second print: 166, 1968, E & S Livingstone Ltd., Edinburgh and London.

16. CHARNLEY, J.: Knee movement following fracture of femoral shaft, J. Bone and Joint Surgery.29:679, 1947.

17. CHERRY, H.L.: A simple efficient extractor for removing clover leaf intramedullary rods, J.Bone and Joint Surgery. 36-A: 400, 1954.

18. CHRISTOPHER'S.: Textbook of surgery, edition.8:1049, reprinted November, 1964, W.B.Saunders Company, Philadelphia and London.

19. COMPERE, E.L., and BANKS, S.W.: Handbook of fracture treatment, edition.4:309, 1958, The year book publishers, Inc. Chicago.

20. COZEN, L., and BROCKWAY, A.: Operative orthopaedic clinic, P.273, 1955, J.B.Lippincott Company, Philadelphia and Montreal.

21. DAS, K.: Clinical method in surgery, edition.4:121, 1956, The City Book Company, Calcutta.

22. DENMAN, C.H.: Medullary fixation of femoral shaft fractures, Amer. J. Surgery.80:666, 1950.

23. DEPALMA, A.F.: The management of fractures and dislocations, Vol.2, Nov, 1966, W.B.Saunders Company, Philadelphia and London.

24. ELISON, EL., and PAULNORTH, J.: End result in fractures of the femur, J.A.M.A.109:848, 1937.

25. FITTS, W.T., JR., and ROBBERT, B.: The effect of intramedullary nailing on the healing fracture, Surgery.,Gynae. and Obst.89:609, Nov, 1949.

26. FOWLER, B.S., and RIORDAN, D.C.: Internal fixation of the femur with Küntscher intramedullary nailing, South. M.J.42:545, 1949.

27. FUNSTEN, R.V., and LEE, R.W.: Healing time in fracture of shaft of tibia and femur, J.Bone and Joint Surgery.27:3, 1949.

28. GARTLAND, JOHN. J.: Fundamental of orthopaedics, P.281, 1965, W.B. Saunders Company, Philadelphia, and London.

29. GASTON, S.R., and OTHERS.: Open reduction and internal fixation of fractures of long bones, J.Bone and Joint Surgery. 31-A: 94, 1949.

30. GRAY'S.: Antomy descriptive and applied, edition. 34:443, 1967, Longman's Green and Co. Ltd., London.

31. GREBE, A.A.: Fractures of the shaft of the femur, the Am. . J. Surgery. 80:161, 1950.

32. HANLY, G.T.: Reduction of fracture of shaft, British Medical Journal. 2:1088, 1939.

33. HAUGE, M.F.: Intramedullary nailing of fractures of shaft of long bones, Surg., Gynae. and Obst. 97:67, 1953.

34. HENDON, G.A.: The treatment of the fracture of the femur, Am .J. Surg. 20:542, 1933.

35. HOGLAND, E.J.: New method of applying autogenous intramedullary bone transplant and making autogenous bone screws, Surg., Gynae. and Obst. 24:243, 1917.

36. HOLLINSHED, W.H.: Functional anatomy of the limbs and back, edition. 2:280, 1963, W.B. Saunders Company, Philadelphia, London.

37. JACKSON, O.J.N.: Impaction in the shaft of the femur of a nail introduced from the fracture site, J.Bone and Joint Surgery. 32-B:704, 1950.

38. KENNEDY, R.H.: Fractures of shaft analysis of 120 cases, ANN. Surgery. 107:419, 1938.

39. KING, T.: Compression of bone ends as an aid to union in fractures. A report on forty-nine un-united and four recent fractures, J.Bone and Joint Surgery. 39-A: 1238, 1957.

40. KÜNTSCHER, G.: Practice of intramedullary nailing, English edition (translated by Herman H.Rinne), 1967, Charles C.Thomas Publisher, Bannerstone House, Springfield, Illinois.

41. KÜNTSCHER, G.: Küntscher technique of intramedullary nailing, Zentralbl - Fur-Chirurgie. 67:1145, 1940.

42. KÜNTSCHER, G.: The küntscher method of intramedullary fixation, J.Bone and Joint Surgery. 40-A:17, 1958.

43. LAST, R.J.: Regional and applied anatomy, edition. 4:290, 1966, J & A. Churchill Ltd., London.

44. LE VAY, A.D.: Intramedullary nailing in Küntscher clinic, J. Bone and Joint Surgery. 32-B:698, 1950.

45. LIPPMAN, R.K.: A case of un-united infected fractures, healed with aid of Maggot treatment, J.Mt.Sinai Hospital.1:138, 1934.

46. LOTTES, J.O.: Blind nailing technique for insertion of the triflange medullary nail, J.Amer. Med.Asso.155: 1029, 1954.

47. LOTTES, J.O.: Treatment of fractures of the femur with heavy large cored three flanged medullary nail, Surgery.29:868, 1951.

48. MACAUSLAND, W.R.: Medullary nailing of fractures of long bones, Surgery.,Gynae. and Obst.84:85, 1954.

49. MAROUDAS, A., and BULLOUGH, P., and OTHERS.: The permeability of articular cartilage, J.Bone and Joint Surgery.50-B:166, 1968.

50. MCGREGOR, A.L.: A synopsis of surgical anatomy, edition.9:500, 1963, John Wright and Sons Ltd.,Bristol.

51. MCKEEVER, F.M.: Fracture of the shaft of femur in adult. Evaluation of method of treatment, J.A.M.A.128: 1006, 1945.

52. MERLE D' AUBIGNE.: Surgical treatment of non-union of long bones, J.Bone and Joint Surgery.31-A:256, 1949.

53. MOYES, T.B.M.: The treatment of certain type of fractures with V_2A steel in medullary cavity (Küntscher method), J.A.M.A.128:792, 1945.

54. MOORE, A.T.: Missing the distal fragment in the fracture of femoral shaft, J.Bone and Joint Surgery.32-B: 702, 1950.

55. MURRAY, G.: The use of longitudinal wires in bones, in the treatment of fracture and dislocations, Amer.J.Surgery.107:156, 1945.

56. NICOLL, E.A.: Impaction of a nail in the sclerotic bone of a fractured femur in paget's disease, J. Bone and Joint Surgery.32-B:705, 1950.

57. PALMER, I. : Review of the complications and technical problems of intramedullary nailing, J.Bone and Joint Surgery. 32-B:721, 1950.

58. PELTIER, L.F.: Theoritical hazards in the treatment of pathological fractures by the Küntscher intra-medullary nail, Surgery, 29:467, 1951.

59. PELTIER, L.F.: Nail design an important factor in intramedullary nailing, Surgery.28:744, 1950.

60. PELTIER, L.F.:Fat embolism following intramedullary nailing, Surgery.32:719, 1952.

61. RAYAN, T.J.: The use of Russell apparatus in the treatment of fractures of shaft of femur, ANN. Surgery.85:529, 1927.

62. RUSSEL, H.P.: Mal-union of fractures of femur, ANN. Surgery.93:984, 1931.

63. SCUDERI, C.S.:Fat embolism, its relation to intramedullary nailing, Journal of Int.College of Surgeon.19:508, 1953.

64. SMITH, H.: Intramedullary fixation, J.Bone and Joint Surgery.32-A:464, 1950.

65. SMITH, H.: Impaction in the shaft of the femur, of a nail introduced through trochanter, J.Bone and Joint Surgery.32-B:706, 1950.

66. SOEUR, R. : Medullary pinning of diaphyseal fracture, J. Bone and Joint Surgery.28:309, 1946.

67. STREET, D.M. : One hundred fracture of the femur treated by means of the diamond shaped medullary nail, J. Bone and Joint Surgery.33-A:659, 1951.

68. STREET, D.M. : Comparative study of skeletal traction, dual plating and medullary nailing, J.A.M.A.143-No.8: 709, 1950.

69. STREET, D.M., and HANSEN, H.H.: The medullary nailing presentation of a new type and report of a case, Arch. of Surgery.55:423, 1947.

70. STUCK, W.G.: Complication of intramedullary fixation of fracture of the femur, Arch.Surgery.63:675, 1951.

71. VANGORDER, G.W.: A critical end result study of 105 conservative cases at Massachusetts General Hospital, Surg.,Gynae.& Obst.64:110, 1937.

72. VENABLE, C.S.: Results of recent studies and experiments, concerning metal used in the internal fixation, J. Bone and Joint Surgery.30-A:247, 1948.

73. VOMSAAL, F.: Reviews of the complications in intramedullary nailing, J.Bone and Joint Surgery.32-B:717, 1950.

74. WATSON - JONES, R.: Extrusion of intramedullary nail from the femur, J. Bone and Joint Surgery.32-B: 710, 1950.

75. WATSON - JONES, R., and COLTART, W.D.: Slow union of the fracture with a study of 804 cases of the shaft of the tibia and femur, British Journal of Surgery.30:260, 1942/43.

76. WESTBORN, A.: Marrow nailing of recent fractures, pseudo-arthrosis and bone plastic, ANN. Surgery.127-A: 577, 1948.

77. WEST, W.K.: Fractures of shaft of femur, J.A.M.A.88:219, 1927.

78. WINANT, E.M.: The use of skeletal traction in the treatment of fractures of the femur, J. Bone and Joint Surgery.31-A:87, 1949.