REVIEW OF LITERATURE
REVIEW OF LITERATURE

The earliest reference to the subject of healing in literature, are found in ATHARAVA-VEDA (2000 BC), CHARAKA-SAMHITA (1000 BC) mentioned a medicated bandage "KAVALIKA". Sushruta (100 BC) has described the fractures as "Kanda-Bhang". Various types of fractures and dislocations are described in Sushruta Samhita. In the treatment of the fractures of lower extremities "Kapat-Shayana" (Door bed) or a fracture board consisting of a plank of wood resembling the panel of a door were used. For the fracture of the lower limb after making the patient lie on the bed, the injured limb was immobilised with the help of pegs.

Apart from these references, no clear concept of treatment of fractures particularly of lower limb was available till the middle of 18th century. Hippocrates was the first to study the effect of muscle spasm on fractures which caused shortening and over riding. Hence splinting the limb to overcome these problems became popular in the middle of 18th century.

Turkish Empire (1798) reported that the setting of bones, were practiced by enclosing the broken bones in case of plaster of paris. Later on in 1852, Adonius Mathysen a Flemish Army surgeon popularised the use of plaster of paris bandages. The limbs were to be immobilised with one joint proximal and one distal till complete union occurred.
The first external fixation for the treatment of fractures was described by Molgaigne (1851). Parkhill (1897) described the use of two half pins above and two half pins below the fracture in long bone, externally joined by an indigenous clamp for fracture reduction and immobilisation.

The technique of walking cast was first developed by Krause (1891) and later by Dollinger and Budapest (1893). They used to apply the unpadded plaster to treat fracture of leg, so that weight might be transmitted from tuberosity of tibia to bottom of plaster.

Lembotte (1913); Grooves (1918) and Rush and Rush (1937) used some forms of nail for intramedullary fixation of tibial fractures.

Oskar Linden (1938) observed in a study of 52 cases treated by conventional method, the average healing time was 22.3 weeks. The average shortening was one to two cm with five to ten degree of valgus deformity in 38.4 percent and varus deformity in twenty five percent cases.

Raoul Hoffmann of Switzerland (1938) developed a four plaster double frame external fixation device. He presented a series of articles describing his method of external fixation from 1938 to 1954.
Gurd (1940) described early weight bearing for the treatment of tibial shaft fractures, advantages and disadvantages of different methods and the unfavourable features from patients points of view.

Griffith (1942) analysed 249 cases of fractures of both bone in the patients treated by closed method of reduction with above Knee plaster of paris cast. The mean time for union was 16.5 weeks and eight cases had non-union.

Robert funstein (1945) reviewed 149 cases of fracture of both bones leg and found average healing time to be 11.2 weeks for clinical union and 30.4 weeks for radiological union. Types of fractures made practically no difference in the rate of healing.

Eggers et al (1949) demonstrated the effect of contact compression factor on the osteogenesis in surgical fractures. They described two forces acting at the fracture sites, the internal force exerted by the mass of the muscle especially in the voluntary contraction and external contact compression exerted by gravity and weight bearing. They concluded that:

1. Presence of contact compression factor stimulates the osteogenesis.

2. Excessive compression fails to stimulate osteogenesis.
Lottes (1952) evaluated the results of 176 fractures of the tibial shaft treated by nailing, plating and plaster immobilisation. The average healing time was six months, 11.8 and 8.4 months respectively. Incidence of non union was 23.7 percent with plating, 10 percent with conservative treatment and none with nailing. As regards the deformity, there was varus or valgus angulation of three degree or more in 19.6 percent cases of conservative treatment, 5.7 percent in closed nailing and 4.3 percent in plate fixation. For the three groups shortening of over 6 cm was in 19.6 percent, 1.9 percent and 4.3 percent of the cases in that order.

Carpenter et al (1952) and Jackson (1959) concluded that 95 percent of tibial shaft fractures, whether simple, comminuted or compound can be adequately managed by closed reduction with the advantage that such conservative means will avoid serious complications and will enable the fractures to heal in a shorter period than a similar fracture treated by open reduction and internal fixation. Their conclusion is that initial haematoma around a fracture contains osteogenic properties which help in healing of the fracture. If this haematoma is exposed to external environment by open reduction, not only the union of fracture is delayed but also chances of infection increases.
Lottes (1954) reported 300 cases of tibial shaft fractures treated by the closed intramedullary nailing. He used Lottes nail. It was necessary to expose the fracture site in only three out of 300 cases all in fresh fractures, because of failure to obtain reduction by closed method. In fresh fractures of tibia with intact fibula, the fibula was osteotomized after the nailing has been completed to allow impaction and weight bearing.

Wade and Campbell (1958) reported discouraging results with the use of plates as compared to other form of surgery. According to them endosteum appeared to assume the sole responsibility for binding the fracture site, but fixed distraction and excess of foreign material made the use of plates hazardous.

Ellis (1958) treated 315 fractures conservatively and recorded average healing time as 10, 15 and 23 weeks for minor severity, moderate severity and major severity of fractures respectively.

Kuntscher (1958) used the improved nail and his method gained popularity. Introduction of strong intramedullary nail combined with the principle of reaming out the medullary canal and the development of image intensifier have recovered interest in closed nailing.
Solheim (1960) studied 500 tibial shaft fractures treated by either closed reduction and plaster of paris cast or open reduction and internal fixation. He found that healing time was shortest with conservative method and that the transverse fractures united earlier.

Dehne et al; (1961) treated fractured tibia by immobilisation in a near skin tight cast with knee held in full extension and with immediate weight bearing. The average time of healing and return to work for all 207 patients was five months. In 86 percent of the patients the time for healing and mobilisation was between four and six months. In remaining 14 percent cases it varied from two to four months.

Alder et al (1962) reported that osteomyelitis developed in twenty percent cases of open fracture treated by medullary nailing and only in 2.2 percent of similar fractures treated without internal fixation. They also stated that Kuntscher nailing cannot be used in comminuted fractures and also in patients below fourteen years of age, because of fear of epiphyseal damage.

Alms (1962) treated a total of 50 fractures of tibial shaft by closed intramedullary nailing for which
no external splint was used and the patient allowed to walk as soon as the wound healed. The average period of absence from work for the patient was eleven weeks. There was no case of sepsis or non union.

Nicoll (1964) in his survey of 705 cases of fresh tibial shaft fractures of which 674 were treated conservatively and 31 were treated by primary intramedullary nailing or plating. He observed the average time of union of fracture was 16 weeks (12 to 20 Weeks). Incidence of delayed and non union in infected cases was 60 percent. Intact fibula showed to hasten the process of healing. Twenty five percent of cases had foot and ankle stiffness. In his opinion "Internal fixation actually delays union unless it is absolutely rigid and this is never the case with intramedullary nailing". But internal fixation can be justified on grounds that it reduced the incidence of functionally significant deformity and joint stiffness, it significantly lowered the incidence of delayed and non-union.

Caladias (1964) and Dankwardt (1969) described that the nutrient artery is destroyed and endosteum and bone marrow is almost completely removed because of reaming and nailing and so more chances of delayed or non union. Endosteal callus formation is scarce. There are chances of fat embolism following reaming of tibia.
Edward (1965) treated 492 fractures with closed reduction and plaster application. The results after one year were analysed as good, fair and poor. Longitudinal fractures showed 85 percent good, 15 percent fair while the transverse fractures showed 95 percent good, five percent poor results. Union time was nine months in closed tranverse fractures and fourteen months in open transverse fractures. Complications such as skin necrosis, osteomyelitis and malunion were observed in four cases.

Muller et al (1965) treated tibial shaft fracture by compression plates. They reported encouraging results with dynamic compression plates and reported 93 percent results as good whereas only six percent complication rate was found in closed group treated fracture of tibia.

Weissman and Herold (1966) treated tibial shaft fracture without internal fixation in 150 cases and found that the average time of union was four months and seventeen days along with average time of hospitalization of seven days. Temporary limitations of movements at knee and ankle was observed in most patients during first few months after plaster was removed. Shortening of leg amounting to 3", 2" , 1½" and 1" respectively was observed in four cases and one case had varus angulation of 30 degrees. Seven patients had pain over the fracture site for more than seven months.
Anderson et al (1966) reported their experience with a method of closed treatment of fractures of tibia and fibula. They used a Steinmann pin through the tibia and closed reduction followed by plaster application. They found certain advantages of this method over closed reduction in cases of unstable fractures of both bones of leg. In only 2.1 percent, union was delayed and in 1.9 percent no union developed out of 128 fractures of the tibia and fibula treated by the above method.

Augusto Sarmiento (1967) advocated the idea that the tibial fractures could easily be managed with the help of below the knee weight bearing cast in total contact, permitting the movements at knee joint. He submitted a report of 100 cases of fracture shaft tibia, who were treated by conventional toe-to-groin cast followed by patellar tendon bearing cast, which was given within six weeks of injury. The average healing time was 14.5 weeks. 78% of all fractures were associated with fracture of fibula, had healing time 13.1 weeks and 22% were associated with intact fibula, had healing time of 15.6 weeks.

Zuckman and Maurer (1969) reported 36 cases of two level fractures of tibia treated by blind nailing of which 17 patients had closed fractures. Primary bone union in good position were obtained in 15 cases and an aseptic union was found in 0.2 percent. No case had
malunion, union with sepsis or septic nonunion. They concluded that both the fractures upper and lower had the same potential for union. In these cases walking was started with full weight bearing in an average time of three to four months and it decreases the rate of non union and infection as compared with other type of fixation devices.

Brown and Urban (1969) presented a series of 60 cases of fractures shaft tibia. After reduction a long leg cast was applied and early weight bearing was permitted. They reported 100 percent union with average period of nineteen weeks. The overall shortening was 9 mm., angulation was less than ten degrees.

Sermeinto (1970) treated 135 cases of fracture shaft tibia by a functional below knee brace and stated that the patient walked with full weight bearing after four weeks of injury. Average healing time was 14.1 weeks in both bone fracture leg and 16.8 weeks when fibula was intact. Average amount of shortening observed was 6.4 mm. No rotation deformity was recognised at follow up but the ultimate degree of rotation of distal fragment was not measured accurately. Several minor pressure sores were encountered in the popliteal fossa.

Birotte and Joseph (1970) treated 75 fresh displaced fractures of tibia by percutaneous multiple pin fixation, short leg cast and immediate weight
bearing reviewed 100 percent healing with an average period of healing between 16 to 20 weeks. They used four pins two in proximal and two in distal fragments but segmental and comminuted fractures needed five or six pins. The mean time for healing was eighteen and half weeks. Oblique fractures healed slowly. There were no instances of non union or delayed union. Secondary, inflammatory reaction in about two pins occurred. Preserved knee motion was associated with early restored ankle and foot motion.

Hamza et al (1971) reported 50 patients with fracture tibia - 28 closed and 22 open treated by intramedullary nailing. Nineteen patients had closed nailing and remaining underwent open nailing. Average time for clinical union was three months. Radiological union was obtained at an average of four months. Average time interval between injury and return to work was 4.5 months. Patients who had developed non union during treatment by other method can obtain union expeditiously after reaming and inserting large size nail.

Burwell (1971) treated 181 cases of fracture shaft tibia by plate fixation and concluded that closed method of treatment is considered to be the safest method.

Gamble et al (1972) treated 100 fractures of tibia by early weight bearing in long leg cast and
evaluated the result close to Brown (1974). Brown concluded that the closed reduction and early weight bearing in long leg cast often concedes minor complication in favour of a predictably high union rate with no major complications and can be used for all types of tibial shaft fractures.

Denis King (1972) submitted his report and said about the original use of below the knee cast in total contact, based on P.T.B. prosthesis. He gave much stress on moulding over medial flare of tibia, popliteal fossa and patellar tendon. P.T.B. cast was given within 5 weeks of injury, following toe-to groin cast. The average time of plaster was 4-5 weeks less in P.T.B. cast and all patients returned to their work 2 months earlier than those treated in toe-to-groin cast. No mal-union, delayed union or non union has been reported.

Olerud and Karlstrom (1972) did secondary intramedullary nailing of tibial fractures. They took thirteen patients who had already been treated with compression plating but due to poor compression achieved they underwent secondary intramedullary nailing after reaming of medullary canal; with regard stability delayed intramedullary nailing has an important advantage namely the endosteal callus which gives nail a firm grip in fracture of lower and upper end to tibia. Out of 13 cases only one had infection which
considerably delayed the healing of fracture. The final results were excellent or good in 87 percent of cases.

Berkin and Mershal (1972) used three sided plate fixation for fractures of tibia. Two plates which were slotted fenestrated and gutter shaped were placed such that its linear margin would be in contact of bone on two sides and an Egger's slotted plate placed along the third side. This assembly did not result into angulation. Ninety two tibial fractures were treated with above method. The overall results were very good in 72 cases, 11 were good and nine were satisfactory. There were six post operative wound infection. Delayed union occurred in 11 patients.

Dunn et al (1973) in their study of 45 closed tibial shaft fractures, treated by P.T.B. cast reported average healing time of 14.1 weeks. Non union occurred in two cases.

Protzman and Burkhaltor (1974) reviewed 440 fractured tibia, 228 open and 212 closed. Open fractures were treated by debridement and toe-to-groin cast with early weight bearing. In 159 of open fractures, both fragments were exposed at fracture site due to soft tissue loss. The average time for removal of plaster cast was 20 weeks for closed and 21 weeks for open fractures and 23 weeks for exposed fractures.
Sarmiento et al. (1974) studied the stability effect of interosseous membrane and soft tissue on tibial shaft fractures treated in below the knee total contact cast. The effect of interosseous membrane were analysed in cadaver and freshly amputated limbs, using morphological, histological and dynamic testing techniques. Effects of soft tissue were demonstrated using a transparent brace with a gel substituted for soft tissue.

Smith (1974) compared the results of early and delayed internal fixation in the treatment of fractures shaft of tibia. He observed that average healing time was 26 weeks in cases of early internal fixation and eighteen weeks in delayed internal fixation. He thus confirmed that in except mild fractures early internal fixation would always increase the time of healing and incidence of complications.

Krenge1 and Romano (1975) reported 59 adults with 60 tibial fractures treated initially by closed reduction and immobilisation in above knee cast, replaced by a weight bearing P.T.B. cast following 21 days. 5 percent angulation and 50% percent loss of apposition were the maximum malalignment accepted. Non union occured in 5 percent of cases, all of them were displaced fractures in distal third. The average shortening was 4 mm and was never more than that seen on
initial X-ray. No symptomatic loss of ankle and knee motion occurred and there was minimal muscle wasting.

Weidmer et al (1975), Fristchy and Burdet (1977) Suman (1977), Dommissie (1978) and Mollan and Brandley (1978) also applied the P.T.B. cast within 6 weeks of date of injury and compared the results with conventional treatment for fractures of tibia. The results were found superior to conventional method.

Karlstrom and Olerud (1975) treated 28 severe, open tibial fractures with stable external frame fixation by the vidal Adrey double frame method. The average time of limb kept in the frame was 4.9 months and then a P.T.B. cast was used. The mean time until full weight bearing without external support was 7.9 months.

Newton et al (1978) also treated the fractures of tibia in age group of 7-16 years with functional cast brace. The average healing time was 13.2 weeks. Two cases had refracture. No patient had restriction of knee and ankle movements.

Trivedi and Patol (1978) used the method of insertion of stienmann pins and incorporating them in a below knee total contact cast in 80 cases of fracture tibia and compared the results with above knee casts. The results showed that the average duration of plaster immobilisation was about same in both the series i.e.
4.2 months in below knee method and 4.5 months in above knee method. The occurrence of delayed union and failure rate were slightly lower in former method. The only complication was pin tract infection and loosening of the pin. Early ambulation with full range of movements at knee minimised the quadriceps wasting.

Sharma et al (1978) treated 45 cases of fracture shaft tibia by intramedullary 'V' nailing. Clinical union was evident by ten to fifteen weeks. Complications developed like deep wound infection in 17.2 percent and bending of nail in 7.4 percent. Patient was allowed to walk with the help of crutches after removal of stitches and was allowed to walk with weight bearing after 6 weeks. The hospital stay was from 11 to 20 days.

Clancey et al (1978) treated 102 open tibial shaft fractures, 56 with cast immobilisation, 35 with internal fixation and seven with external fixation. Average time of healing was 19.5, 19 and 28 weeks respectively. Deep infection developed more in cases with internal fixation (11 percent) than in cases treated with cast immobilisation.

Sharma et al (1979) studied 258 fractures of tibia treated in below knee cast following toe-to-groin conventional treatment. The average time for union was 15 weeks. The fractures with intact fibula healed earlier than fractures of both bone leg.
Edward et al (1979) reported the study of 44 open tibial fractures. Seventy-three percent of cases had bone loss or major comminution. After initial debridement double frame Hoffmann apparatus was applied and fracture reduced. Initial union was evident at four months, complete at seven months. Thirty percent of cases developed pin tract infection which cleared off after removal of pins.

Linden and Larson (1979) in a randomized trial of 100 transplanted fractures treated conservatively or by A.O. plating, found that complications in the A.O. group were more common. Their stay in the hospital was more, delayed union more frequent, but A.O. group healed faster with average time of 12 weeks as compared to the conservative group where healing time was 17 weeks whereas open fractures healed faster when treated conservatively.

Bhargava and Sethi (1981) treated 85 fractures of tibia with below the knee cast following a toe-to-groin cast of an average 2 weeks. During this time, weight bearing on crutches were encouraged. P.T.B. cast was given in manner described by Sarmiento (1967) with few modifications:

i) The cast was extended upto proximal pole of patella to prevent bunching of patellar tendon, when patients knee extended after full flexion.
11) A wooden log was applied to improve toe-to-heal gait.

The results were found to be encouraging and reported average clinical union 13.7 weeks, radiological union 15.8 weeks. The average shortening was 1.1 cm. The knee had good range of movement after 3 months with average flexion 110° and no extension lack.

Groose Kempf (1982) used interlocking tibial nail which have holes through their proximal and distal ends and are used for fractures of proximal or distal third of tibia, segmental fractures and fractures with significant comminution.

Traditional half frames are safe and provide excellent wound access but are not rigid enough to hold unstable fractures to deal with heavy limbs, or to permit early weight bearing (Schmidt and Rorback, 1983). They reported loss of reduction in 15 percent of their cases.

Transfixation of ankle and foot dorsiflexors more distally may lead to permanent ankle stiffness. Emerson and Grabies (1983) followed up tibial fractures immobilized with bilateral frames and found that the most frequent complaint was ankle and foot stiffness. Apart from neurovascular injuries and permanent joint stiffness pin tract infection have been the most serious
limiting factor in the use of traditional unitateral or bilateral frames.

Mayer et al (1985) treated 51 severe fractures of the tibial shaft with multiple intramedullary Enders nail. Forty one fractures united in less than four months and eight within four to eight months. Only two were not united even after eight months.

Lawrence and Kenneth (1986) treated 112 fractures of the tibia by manipulation reduction, reaming of medullary canal and fixation of fragments with an intramedullary nail either ASIF/AO or interlocking nail. Follow up evaluation was performed in 100 fractures. The average time of union of fracture was 19 weeks. Two patients had delayed union. Deep sepsis developed in seven percent and superficial in two percent.

Rao and Shahne (1986) treated 103 tibial shaft fractures by closed intramedullary V nailing without image intensifier. Patients were allowed to bear full weight in patellar tendon bearing cast. By twelve weeks 91 fractures had united while at 18 weeks only three had non union. Four patients needed re-operation for sequestrectomy and delayed union.

Mohindra and Nath (1987) treated 36 cases of fresh open fracture shaft tibia with direct current stimulation. They concluded that the increase in current strength did not alter the rate of fracture union. There
was only a marginal improvement in the rate of union, following electric stimulation as compared to the treatment by a P.T.B. cast alone.

Oni et al (1988) treated 100 cases of closed tibial shaft fractures by closed methods. They observed that by 20 weeks 19 fractures had not united, but 15 of these had united by 30 weeks with conservative treatment alone. The remaining four cases were operated upon because no further progress in healing was anticipated. They concluded that open reduction and internal fixation is rarely justified, in closed adult tibial shaft fractures with regard to healing.

Venysarkar and Laud (1990) treated 54 tibial shaft fracture with functional cast bracing. They observed extremely satisfactory results from different points of view with an union rate of 96 percent.

Sanjay and Misurya (1990) treated 50 open fractures of tibial shaft by transverse pin fixation, combined with below knee plaster cast and early weight bearing. Union was observed in all fractures after 10-22 weeks (average 16 weeks).

Alho et al (1990) treated 93 tibial shaft fractures with Grosse-Kempf locked nail. Half of fractures were united radiologically by 15 weeks. The 26 fractures which remained statically locked, and were not
Dynami\-s\-ed, healed in an average of 16 weeks, while those with dyna\-mic locking healed in 14 weeks.

Hooper et al (1991) treated 62 tibial shaft fractures conservatively or by closed nailing and concluded that intramedullary nailing gave more rapid union with less mal union and shortening.