TREATMENT OF TIBIAL FRACTURES IN BOVINES WITH RUSH PINS

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BY

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CERTIFICATE

This is to certify that this thesis/dissertation entitled "TREATMENT OF TIBIAL FRACTURES IN BOVINES WITH RUSH PINS" submitted for the award of degree of M.Sc. (Veterinary Science) in the major subject of Surgery, of the Andhra Pradesh Agricultural University, Hyderabad, is a result of bonafide research work carried out by K. VENKATESWARA RAO, B.V.Sc., under my supervision and that the thesis has not formed in whole or in part, the basis of the award of any degree, diploma, or other similar degree or distinction by any other University.

(Signature)

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My thanks are due to Dr. Neils Iver Heje of F.A.O. Veterinary Faculty, Denmark for supplying rare literature on splints etc.

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K. Venkateswara Rao.

K. VENKATESWARA RAO

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INTRODUCTION

TREATMENT OF TIBIAL FRACTURES IN BOVINES WITH RUSH PINS

Surgical treatment of fracture is of a comparatively recent date. During the pre-antiseptic period there were only sporadic descriptions about it in the medical literature. With the introduction of antisepsis and asepsis it gathered momentum and by the beginning of this century this problem was discussed thoroughly by the human surgeons (Sonnichson, 1964). But tremendous advances have been made only during the past 40 years. Veterinary surgeons not only adopted these methods for small animals but some like Otto Stadar (1931) even stole a march over them by introducing a mechanical splint in which both the principles of external and internal splinting were combined (O'Conner, 1950). However, they have been avoiding to a great extent the treatment of fractures in large animals especially those above the hock and knee owing to the difficulties in reduction, immobilisation, ambulation and post-operative care. Further, not only the owners have been non-cooperative due to the high cost of treatment, unusual labour involved and uncertain utility of the animal after treatment, but also the animals in the form of heavy weight, restive temperament and complex digestive tract. In spite of the foregoing the Indian veterinarian due to the sentiments of the people has to take up the treatment. Literature on this mainly consisted of reports on incidental cases in which treatment usually was successful but without logical discussion. Fractures in which treatment failed were neither referred to at all nor were discussed with sufficient degree of criticism (Khan, 1967). It also revealed only a few and limited systematic studies (Gill, 1970). Therefore it has been decided to take up surgical treatment of one of the difficult fractures in large animals for a systematic study.

The province of Andhra Pradesh depended not only on cows and buffaloes for milk but also on bullock power for agricultural operations. Therefore, fractures in cattle and buffaloes have been taken up for this purpose.

According to the statistics available, the most common fracture in cattle admitted to the college clinic at Tirupati is of Tibia. Moreover, it is the most difficult to treat and in the past was listed among the incurable fractures (Kendrick,1951). Therefore, tibial fractures have been taken for this study.

Various methods of immobilisation have been published for tibial fractures in large animals. But every method has its own drawbacks and limitations. Further, they are not simple, practicable and not always successful under field conditions. Therefore a new method has been thought of. The only method of immobilisation that appears to have not been tried in bovines is Rush intramedullary pinning. Rush intramedullary pins have several good points. Following are the principal advantages given by Carney (1952) after his trials in small animals.

1. Introduction of the pin from the sides, as well as from either end of the bone, is practicable.
2. Temper of the metal used for the pin is such that the pin is malleable enough to take a curve to enter the bone and resilient enough to realign itself within the bone following gutters on the surface of the medullary canal.
3. The hooked head of the pin is designed to prevent migration into and out of the bone, and facilitates ease in removal, if desired.

4. The sled-runner point simplifies introduction of the pin into the medullary canal.

5. Three-point pressure exerted within the medullary canal prevents displacement or rotation.

6. The pin provides secure fixation without the necessity of impacting with large bars.

7. Fixation utilises normal longitudinal muscle pull.

8. It makes possible adequate fixation of fractures near joints.

9. No complicated nor expensive instruments are required for their application or removal.

10. Versatility. It is useful in all long bones.

11. Removal of the pin after adequate healing is optional

12. Necessary hospitalisation period is comparatively short.

But as these pins could not be procured, clover cross-section pins designed by Dr. D.F. Walker were tried. Their failure made us to try the Rush Pins at all costs. The surgical companies all over India were contacted. Only one company responded. On receipt of the stocks systematic study with Rush pins was started.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The literature on tibial fracture in large animals was reviewed under anaesthesia, plaster of Paris cast, modified Thomas splint, transfixation, bone plates, intra medullary pins, Rush pins, metallic implants, slings and ambulation.

ANAESTHESIA:

Kendrick transfixed in 1949 tibial fractures under chloral hydrate narcosis. In 1951, he used pentobarbital sodium with coramin for animals below 500 lbs, and chlora hydrate and magnesium sulphate for animals above 500 lbs. Ganis (1952) gave nembutal intravenously for induction, and 2:1 chlormag solution and nembutal for maintenance. Guard (1953) recommended "general anaesthesia, such as chloral hydrate intravenously, plus the injection of som 2% local anaesthetic solution into the damaged tissues". Mohanty (1970) used chloral hydrate and magnesium sulphate mixture intravenously to produce sedation and relaxation. Gill (1970) tried on 3 groups of animals general anaesthesia with 6% chloral hydrate, epidural anaesthesia along with chloral hydrate sedation and sparine at the rate of 2 mg. per Kg body weight and concluded that general anaesthesia was suitable for the reason that the period of post-operative quietude was sufficient for the setting and hardening of plaster of Paris cast.

PLASTER OF PARIS CAST:

Bohler (1936) recommended immobilisation of fracture with unpadded plaster of Paris cast keeping the joints of the limb in a position midway between extension and flexion to avoid tension (O'Conner, 1950). Singh and Rao (1954) used unpadded plaster cast for tibial fractures immobilised with bone plates and external bone pins. According to Reichel (1956) the unpadded plaster cast on the hind limb is too cumbersome and immobilises the whole animal. According to Beckenhauer (1958) casts to be effective must immobilise the bone fragments and this is possible only if the soft tissues between the cast and the bone are of limited thickness; large muscle masses located over the upper humerus and tibia allow excessive movement. The cast also must immobilise articulations at either end of the fractured bone; it is difficult to extend the cast above the stifle or elbow joints in large animals; therefore the usefulness of the cast is limited to fractures below carpus and tarsus Gill (1970) used unpadded plaster of Paris coaptation alone in tibial fracture with satisfactory results. He applied the bandage around the hock in figure '8' fashion and extended it up to the tibia and came to the conclusion that fixation of splint at the hock and tucking in of the bandage at the upper end of splint nullified the tendency of the cast to slip down, and omission of padding below the cast prevented rotation

THOMAS SPLINT:

Thomas (1939) used in a horse a modified Thomas splint with anteroposterior frame for anchoring the board splint applied for immobilising the tibial fracture. When the fracture became compound, it was removed and a different type of support was devised. To prevent sideward movement of the bone the fracture was supported medially by means of a well padded strap iron anchored to the anterior and posterior rods of the frame, and laterally by 1"x6" board fixed in a similar manner. To hold the hock in position a short piece of 1"x4" board was inserted posteriorly beneath the posterior rod of the frame. It was removed after 72 days and the animal was kept in slings for two weeks, sling and exercise for two weeks and only exercise for two weeks. Calcium gluconate was given in the feed. Gish (1941) employed for tibial fracture in a bull a modified Thomas splint with anteroposterior frame made from a pipe 17 feet long

3/8" in diameter. It was first bent in the middle, to make a loop, next around it until the ends were parallel to the leg in front and behind. Then the ends were bent to the shape of the leg in natural position. Finally one end was bent between the claws and secured behind to the opposite end to complete the antero-posterior frame. A light wooden splint was placed across the fracture and secured at both ends to the pipe. To this board the fracture site was bandaged. Finally a second complete wrapping of the entire leg including the splint was made. Splint was removed after 32 days. Six out of eight cases recovered Alston (1942) in a cow partially immobilised a tibial fracture with baling wire to a brace made by using 1¼" water pipe. Points of contact were padded and foot fastened to it with a card. Guard (1953) made use of the full length Thomas splint for fractures of tibia. Beckenhauer (1958) devised a splint with partly detachable lateromedial frame and an extension device for tibial fractures in cattle. First the ring splint was applied and riding was overcome by extension. Then lateral deviation of lower fragment was first corrected by means of cotton rope applied to the leg and medial rod and fragments immobilised with plaster of Paris bandage. After two weeks, when the pressure necrosis occurred on the flap of the flank, the ring splint was replaced by a bar splint and left in position for 2 to 4 weeks. According to Lundvall (1960) results obtained in large animals with the Thomas splint and certain of its modifications have not been as satisfactory as those obtained in small animals, because of the mechanical difficulty in shaping the thick pipe or rod into a splint of desired form, decubital ulcers at the junction of the leg and trunk, difficulty in defecation, urination,getting up and walking when applied to hind limbs. However, he admitted that it was most useful in the treatment of fractures in calves and fractures of the tarsus and tibia in horses, when used as a supporting device with plaster of Paris cast. Springstead (1969) treated oblique fracture of tibia in a horse with a combination of coaptation plaster cast and modified Thomas splint and the animal was confined in a sling for about 18 weeks. Mohanty(1970) obtained satisfactory results with modified Thomas splint made of iron ring and two bamboo splints in case of tibial fractures. They walked lame from 15 days to 2 months.

TRANSFIXATION:

Kendrick (1951) immobilised tibial fractures with one layer of plaster of Paris cast anchored to four pins, two from each side, inserted in the proximal fragment and pressed by two pin rods on the sides and second layer of plaster of Paris cast. An abscess in the medullary cavity resulted in an experimental case due to one contaminated end of a pin passing through it during the withdrawal of the through-and-through pins inserted in case of radial fracture. Ganis (1952) tried 3 pins for tibial transfixation, two in the proximal segment of tibia and the 3rd in the metatarsus. Limping was present for about six months. Singh and Rao (1954) tried external fixation of bone pins aided by unpadded plaster of Paris cast in 3 cases of bovines with tibial fractures. Reichel (1956) passed two pins driven latero-medially in the uninjured epiphysis of the injured bone, when this was not possible through the epiphysis of the following bone and bridged them by means of lateral and medial plaster of Paris longetts and iron plates screwed down to the pins and reinforced it by a circular plaster of Paris cast. Perubalsam seal was used to prevent infection from passing in through the pin holes. In the experience of Beckenhauer (1958) the use of Kirschner apparatus in tibial fractures in bulls was unsatisfactory as the patient would not attempt to stand or ambulate and the development of severe osteomyelitis was routine.

Lundvall (1960) adopted, for tibial fracture, through-and-through pins and external bars with plaster of Paris cast enclosing the protruding portion of the 'pins and bars' as they were not sufficiently strong to support the animal. Robert (1960) repaired tibial fracture in a mature bull by using two 18" long 6 mm thick welding rods for transfixation, and two 12"x1½"x½" iron splints drilled to suit the pins and four clamps for immobilisation. Plaster padding was provided to the iron splints to avoid damage from local pressure. Bower and Webb (1963) successfully repaired a tibial fracture in a calf with tarsal dislocation by means of transfixation with Steinmann pins and aluminium plates. Mohanty (1970) resorted to transfixation with plastering. One out of 4 developed osteomyelitis.

BONE PLATES:

Singh and Rao (1954) tried bone plating aided by unpadded plaster of Paris cast for a tibial fracture in a heifer. Hickman (1957) resorted to bone plating for tibial fractures in three bovines. Lundvall (1960) immobilised a tibial fracture in a horse with stainless steel plates and plaster of Paris cast. Gertson and Brinker (1969) suggested the medial approach for the fracture of tibia which is often shattered to many pieces when fractured.

INTRAMEDULLARY PINS:

Singh and Rao (1954) tried intramedullary pinning in two cows with tibial fracture. Bohlers (1955) opined that intramedullary pinning will not be "satisfactorily effective" in maintaining the alignment due to the fact that the superior and inferior extremities of long bones are of greater diameter than the shaft and most part of the bone is cancellous. They restricted its use to transverse mid-shaft fracture, and to femur. Hickman (1957) did intramedullary pinning in a bull with tibial fracture but it was destroyed 3 days later. According to Lundvall (1960), certain technical difficulties concerning insertion (opening the joint in certain locations) and the necessity of giving added support (plaster of Paris cast or a Thomas splint) to the fractured member for some time after insertion of the pin(s) preclude the wide spread use of intramedullary pins. American Association of Equine Practitioners(1965) stated that tibial fractures in young horses treated with marrow nails, had given good results (Sonnichsen, 1965). Orthopaedic research committee (1966) recommended intramedullary nailing for transverse and short oblique tibial fractures in equine weanlings. According to Anderson (1966) in fractures fixed with intramedullary pins peripheral callus only unites the fragments and the rigidity of fixation is inversely proportional to the amount of cartilage in the callus; in snugly fitting, tightly remaining nails bony union occurs much more quickly, and in loose fixation the callus forms,through cartilagenous stage; so, intramedullary pinning is justified only when the stability provided outweighs the biological disadvantage (destruction of bone marrow) and controls the rotation.

RUSH PINS:

Carney (1952) not only acquainted the veterinary practitioner with Rush intramedullary pin, its advantages and its practical application in small animals, but also used it in one case involving the fracture of a weight bearing long bone of a cow. However, he neither gave the end result of his trial on the cow, nor his opinion about their use in large animals. Lawson (1958, '59 and '63) used Rush pins for immobilisation of fractures close to the joints in domestic animals and pointed out that more firm fixation can be obtained with them than with Steinmann pins. American Association of Equine Practitioners (1965) recommended the Rush pin for fracture of olecranon with displacement. Sharma (1969) tried Rush pins in condylar, supracondylar and epiphyseal fractures of femur in dogs.

METALLIC IMPLANTS:

According to Annis (1969), implantation causes a local response resulting in either encapsulation by connective tissue or bone, or rejection or breakage. He gives the following also as the most important specific causes of corrosion.

1. An area of low oxygen potential acting as an anode and relatively high oxygen potential acting as a cathode at and around the contacts or crossings of pins respectively.
2. Transfer of minute particles of a metal to the implant from an instrument made from a different alloy.

SLINGS:

Support of the animal in various types of slings had been employed in the treatment of fractures of the long bones especially those of radius, tibia and femur by Thomas (1939), Lundvall (1960) and Springsted (1969) in horses. According to Beckenhauer (1958) cattle do not respond satisfactorily to sling support; its neck band compresses the oesophagus, prevents eructations and causes tympany; the temperament of the patient is such that it makes no effort to support itself on the functionally sound limbs but depends entirely on the sling for support; this contributes to the rapid development of pressure necrosis at areas of sling contact and deterioration of patients general health.

AMBULATION:

McCunn (1953) wrote that the ambulatory methods of fracture treatment, adopted by modern surgeon, kept the fractured part absolutely immobile but permitted the animal to use the limb instead of keeping the entire limb at rest as in the old methods. According to Reichel (1956) there is no better after-treatment than the free active movement of the animal as this prevents damage to the circulation, atrophy of the muscles and bones and stiffness of joints.

SURGICAL ANATOMY

SURGICAL ANATOMY

Not only it is essential to know the structures in the regions of leg and stifle used for Rush intramedullary pinning and pressed by tibial splint for correct pinning and effective splinting respectively but also the structures around the common fracture sites to know the deviations of fractured fragments and to enable gentle reduction and avoid complications. Anatomical points are described bearing this in mind.

TIBIA:

The shaft is distinctly curved, three sided in the upper two thirds and smaller and flattened from before backwards in the lower one third. It has three surfaces and three borders (Fig. 3).

The anterior border is prominent in its upper third forming the crest of tibia. The rest of its extent is rounded and indistinct. The crest presents at its lower limit, on the medial aspect, a rough prominence for the insertion of semitendinosus and a part of biceps femoris. The lateral border is concave and has the fibrous part of fibula applied against it. Through the space between them the anterior tibial vessels pass outwards and forwards. The medial border (Fig. 1B is thick and rounded in its upper fourth and gives attachment to popliteus muscle.

The lateral surface (Fig. 1A) is wide above and gradually inclines distally to the front of the bone and lodges the muscles of dorsolateral aspect of the leg. They are complex muscle (peroneus tertius, medial digital extensor and common digital extensor) in front, tibialis anterior beneath it, peroneous longus on its lateral aspect and lateral digital extensor behind and beneath the latter. Posterior cutaneous nerve (external saphena) emerges under the posterior part of the biceps femoris, passes subcutaneously in front of the Achillis tendon and terminates on the lateral aspect of the hock. The recurrent tarsal vein, forming on the lateral aspect of the hock, passes up the leg in front of the posterior cutaneous nerve, then under biceps femoris and joins the posterior femoral vein. The peroneal nerve passing over the lateral head of gastrocnemius, descends behind the lateral ligament of the stifle, over the soleus and divides into superficial and deep branches. The superficial branch passes over the soleus and lateral digital extensor, and down between it and peroneus longus and on the lateral aspect of the hock over the annular ligament. The deep peroneal also passes down between the lateral digital extensor and peroneus longus but deeply, then between lateral and common digital extensors and through the annular ligament of hock. The anterior tibial artery the continuation of popliteal artery, from behind the stifle, passes deeply under popliteus turns outward and passes under the lateral condyle of tibia and the origin of lateral digital extensor and gains the lateral face of tibia and is placed along the lateral border of tibialis anterior. The satellite veins are two and are placed one on either side of the artery. It passes down the leg gains the company of the deep peroneal nerve lower down and passes over hock.

The medial surface (Fig. 1B) is slightly convex. In its upper third, it is broad and rough for the attachment of medial ligament, sartorius, gracilis and semimembranosus. Below this it is narrow, smooth and subcutaneously placed. Saphenous artery and nerve descend the medial aspect of the leg subcutaneously and reach the hock, whereas the saphenous vein ascends up subcutaneously to the medial condyle. Tibial nerve, the continuation of the sciatic, runs over the popliteus and deep flexor, emerges under the medial head of the gastrocnemius, runs subcutaneously in front of the Achillis tendon on the medial aspect of lower part of the leg.

The posterior surface (Figs. 3, 1A & B) is flat and wide above and lodges the muscles of the posterior aspect of the leg. They are gastrocnemius and soleus superficially, superficial flexor beneath them, superficial and long heads of deep flexor deeply, popliteus above and deep part of the deep flexor below. Posterior tibial artery detached from the popliteal artery behind the stifle runs down the posterior face of the popliteus and between this muscle and superficial flexor.

The proximal extremity (Fig. 3 and 1A & B) is large and is made up of two condyles, a tuberosity and a spine. The tuberosity is anterior and is continuous distally with the tibial crest and is for the attachment of three straight ligaments of the patella. The condyles are medial and lateral and are for the corresponding condyles of the femur and menisci . The lateral condyle has the rudimentary fibula fused with it on its lateral aspect and serves for the attachment of the lateral ligament of the stifle. Medial condyle gives attachment to medial ligament of stifle.

The distal extremity (Fig. 3) is smaller than the proximal one. Its articular surface presents two deep sagittal grooves for astragulus. It is bounded medially by the fused malleolus, and laterally by the articulating lateral malleolus (distal extremity of fibula).

The medullary canal is slightly curved, wider close to the extremities and narrow in the middle of the shaft.

STIFLE:

It is composed of femoro-patellar and femoro-tibial articulations (Figs. 1A & B).

Femoro-patellar articulation (between patella and trochlea of femur) is provided with a loose capsular ligament (forming a pouch under the insertion of quadriceps muscle), two ligaments, medial and lateral (extending from the corresponding faces of the condyles of femur to the lateral and medial angles of the base of patella) and three straight ligaments, lateral, middle and medial (extending from the patella and its fibro-cartilage to the anterior tuberosity of tibia).

The femoro-tibial articulation (between the condyles of femur and tibia) is provided with a capsular ligament (attached to the margins of articular surfaces of femur and tibia, convex borders of the menisci and cruciate ligaments), two interarticular cartilages, lateral and medial, two collateral ligaments, lateral and medial (extending from the corresponding condyles of femur to the fibula and to the medial condyle of tibia) two cruciate ligaments, anterior and posterior, (the former extending from the tibial spine, upwards and backwards, to the lateral part of the intercondyloid fossa of the femur, and the latter extending from the tubercle medial to the poplitěal notch, upwards and forwards, to the anterior part of the intercondyloid fossa of femur) and a membranęous posterior ligament (enclosing the joint behind).

Posterior muscular mass (Fig. 1C) consists of gastrocnemius, surrounded by biceps femoris laterally, semitendinosus posteromedially and semimembranosus medially.

MATERIALS AND METHODS

MATERIALS AND METHODS

Cattle and buffaloes, intramedullary pinning under intravenous chloral hydrate anaesthesia, and external splinting with a short modified Thomas splint, formed the materials and methods.

PLAN

1. Trying simple anaesthetic methods and selecting the method most suitable for pinning the fractured tibia.
2. Trying various fracturing methods and adopting an easy method of fracturing the tibia for the experiments.
3. Trying intramedullary pins - Walker's and Rush - on the fractured tibia and taking the pin that can be driven easily and that can bring about immobilisation effectively.
4. Trying the pin selected on experimental and clinical cases of tibial fractures and recording the results.
5. Evolving a procedure for immobilising the tibial fracture with the experience gained in the experiments for use by field veterinarians.

MATERIALS

ANIMALS:

Twenty nine animals - 1 bull, 10 bullocks, 3 bull calves, 11 buffalo bull calves, 2 buffalo bulls, 1 cow and 1 heifer, for trials and experiments.

ANAESTHETICS:

Procaine hydrochloride and chloral hydrate for regional and general anaesthesia respectively.

BACTERIOSTATIC AGENTS:

Sulphanilamide powder, Streptopenicillin, Omnamycin and Terramycin to prevent osteoperiostitis and osteomyelitis.

INJECTION EQUIPMENT:

Record syringes of 10 ml, 20 ml and 50 ml capacity, intravenous apparatus with Murphy's drip and 16 gauze hypodermic needles of 2" and 4" length for intravenous and intramuscular injections.

FRACTURING TOOLS:

Two wooden blocks, iron bar, round and angular iron rods, chisel, hammer and sledge hammer for fracturing the tibia.

PINNING INSTRUMENTS:

Rush and Walker's pins, intramedullary pin and electric drills, hammer, cutting pliers and 18 gauze wire for insertion and removal of pins in case of wrong pinning.

Straight cylindrical stainless steel rods (Steinmann pins) of 3 mm and 4 mm diameter with trocar point, fitted to an electric drill in older animals and to intramedullary pin drill in younger animals were used for drilling the bone.

Two types of pins, one given by Dr. D.F. Walker and the other introduced by Rush and Rush (1949) were taken for the study.

Walker's pin (Fig. 2B) is wider and truncated at one end and pointed at the other end. Its cross section resembles a star.

Rush pin (Figs. 2C & 3C) is a round stainless steel rod with curved sled-runner like point at one end and a hook at the other end, which faces in the same direction as the slightly curved point. The point guides the pin up or down the medullary canal without displacement of its contents. The hook when the pin is completely driven into the medullary canal becomes fixed over the cortex of the bone at the point of entry and prevents migration. "When properly applied the pin exerts 3 point pressure by counter force and secures fixation by a spring principle that allows muscular compression of the fragments after alignment. This tends to give solidity and at the same time enhances union" (Carney, 1952).

The nail is made of 18/8 SMo stainless steel which is said to be inert (non-currosive, non-electrolytic and non-magnetic) and can be had in required diameters and lengths. As some of the Rush pins supplied by the company were unsuitable for certain sizes of animals and were defective in their tips, suitable pins with correct tips were made from the 18/8 stainless steel rods got from a Madras trader.

A rod ¼" less than the length of the bone to be pinned was taken and one end was rasped to curve it into a sledge-runner like point and ¼" of the other end was bent into a hook. All sharp edges and hammer marks were removed with a special file and the scratches made smooth with a special emery paper. It was polished in a local company and was not immersed in hot nitric acid to give it a protective oxide coat.

SPLINTING EQUIPMENT:

Short modified Thomas splints, breast drill, 14-18 gauze wire and bandages to apply the splint and fix it.

Each splint (Fig. 2A) consisted of an oval ring and a 'V' shaped frame fixed lateromedially and at right angles to the ring. Iron rod, three and a half times the length of the limb from stifle to foot, was taken. First an oval loop, which encompasses the upper extremity of tibia and when applied allows 2" space around it, was made separately from this rod and hooked behind. The remaining rod was bent in the middle and made into a 'V' like frame. Its ends were bent outwards into hooks and fixed to the ring laterally and medially in such a way that they enclose 1/3 of the loop in front and 2/3 behind (Fig. 9). Small inward curve (foot curve) was made in its stirrup for securing the foot wire. When this was made, the 'V' frame will be slightly longer than the limb. Finally, the frame was bent to suit the hock bend as was done by Gish (1941)

METHODS

Simple methods of anaesthetising the hind limb, fracturing the tibia and pinning the fractured bone were tried, the unsuitable ones were abondoned and suitable ones described.

ANAESTHESIA:

Sciatic nerve and epidural blocks were induced by making perineural and epidural injections respectively with 2.5% procaine hydrochloride solution. General anaesthesia was induced by injecting intravenously, 10% chloral hydrate solution (Table 1).

TABLE I - ANAESTHESIA

).	Date	Animal	Anaes-thesia	Anaes-thetic	Remarks
,	3-11-70	Bullock (O.S.* class)	Sciatic nerve block	Procaine hydro-chloride	Slight sensation present. Muscular relaxation un-satisfactory.
	4-11-70	Bullock (Old grey)	Sciatic nerve block	Procaine hydro-chloride	-do-
	5-11-70	Bullock (Dark grey)	Epidural analgesia	Procaine hydro-chloride	Desensitised but no muscular rela-xation.
	6-11-70	Bullock (Brown)	Epidural analgesia	Procaine hydre-chloride	-do-
	7-11-70	Bull (Grey)	General anaes-thesia	Chloral hydrate	Deep narcosis. Reduced skin sensation. Slight muscular relaxa-tion.
	9-11-70	Bullock (Old grey)	General anaes-thesia	Chloral hydrate	Surgical anaes-thesia, first plane. Good muscular relaxa-tion.

).S.: Operative surgery

As the desensitisation and muscular relaxation were good trial No.6, it had been decided to induce general anaesthesia for operations in the experimental and clinical cases by injecting slowly 10% chloral hydrate solution intravenously, until the nystagmus ceased, anus became flaccid, tail limp, anal reflex was abolished, skin sensation was lost and copious saliva started flowing down the mouth.

FRACTURING:

Two wooden blocks were kept under the leg and in one case the region in between the blocks was struck from above with an iron pipe. In two cases, round iron rod and angular iron rod were kept on this region and struck with a sledge hammer. In the fourth case the skin of the leg was incised on the medial aspect aseptically, bone exposed, chisel applied across the bone and was struck with an orthopaedic hammer and the wound closed with sutures (Table 2).

TABLE 2 - FRACTURING METHODS

No.	Date	Animal	Tools used	Remarks
1.	17-11-70	Bullock (O.S.class)	Iron pipe only	Fractured after several blows. More violence. Undesired, compound, multiple fracture.
2.	23-11-70	Bullock (O.S.Class)	Iron rod and sledge hammer	-do-
3.	25-11-70	Bullock (O.S.class)	Angular iron rod and hammer	-do-
4.	26-11-70	Bullock (O.S.class)	Chisel and hammer	Desired fracture with less tissue damage.

As fracturing the bone with chisel and hammer was easy and was associated with less tissue damage, it had been decided to try this method for fracturing the tibia in experimental animals.

PINNING:

First, Walker's pin was tried in three animals. In two animals stifle was flexed, a small cutaneous incision was made on the medial side of the anterior tuberosity of tibia, pin point was applied on the bone and driven down with a hammer after the reduction of the fracture. In the third animal the bone was drilled with a Steinmann pin fixed to an electric drill and the pin was driven through the hole with the hammer (Table 3).

TABLE 3 - TRIALS WITH WALKER'S PIN

No.	Date	Animal	Drill hole	Remarks
1.	30-11-70	Bullock (O.S.class)	Without drilling a hole	Pin entered the bone and came out of the fracture site. Removal of pin is too difficult. Position is inconvenient. No working space.
2.	3-12-70	Bullock (O.S.class)	Without drilling a hole	-do-
3.	3-3-71	Bullock (Old grey)	Hole made with electric drill and Steinmann pin	Soft tissue twisted round the drill bit and caused more tissue damage.

This pin had been abondoned as a lot of inconvenience was experienced in driving the pin and as there was some tissue damage when drilled and as the pin was very weak.

Rush pins were tried on 7 animals. Three sites for driving the pins were selected. Proximal medial site was on the medial aspect of the anterior tuberosity of tibia. Distal medial and distal lateral sites were just above the respective malleoli. The skin and subcutaneous structures in the pinning site were incised and retracted. A hole was made in the bone with a Steinmann pin and intramedullary pin drill, first keeping the pin at right angle to the bone to make a bed, then at an acute angle to make an oblique opening until the medullary canal was entered. The fractured fragments were then reduced, the pin was driven through the hole (Fig. 3) with the curve of the sledge runner tip directed downwards and its sharp edge upwards until the whole length of the pin except the hook was inside the bone (Table 4).

Proximal medial site was successful in six cases but some inconvenience in driving the pin was felt. Distal medial site was successful in four cases and distal lateral site in five cases. Proximal lateral site was not tried in view of the heavy musculature

TABLE 4 - TRIALS WITH RUSH PINS

No.	Date	Animal	Nature of fracture	No. of pins	Pin site	Result	Supplementation	Remarks
1.	27-4-71	Buff. calf	Transverse	Nil	PM	Two attempts failed.	..	Difficult to drive the pin in PM site due to want of working space. Pin points defective. Company pins not malleable.
					DM	Failed. Tip corrected, again failed.		
					PM	Again failed.		
2.	4-5-71	Buff. calf	Transverse	Two 3 mm thick	PM	Successful.	..	In DL site the bulge of the lateral malleolus caused difficulty in making the angle between the pin and bone more acute. Pin bent when fracture site was bent.
					DL	Failed. Passed when tip corrected.		
3.	5-5-71	Buff. calf	Transverse	Three 3 mm thick	PM	Pierced the opposite cortex; passed when tip bent.	..	May be due to wider angle, straight tip or bed formation by the drill bit on the opposite wall of medullary canal. Pins bent even though increased in number.
					DM	Passed.		
					DL	Passed.		
4.	17-5-71	Bull calf	Oblique	Three 4 mm thick	PM	Failed, entered when second hole was made.	..	4 mm pins were tried to increase the strength but they failed. Passed when bent. Malleability appears to be more important. All the pins bent when the fracture site was bent. Marrow came out when the third was driven.
					DM	Failed, passed when bent.		
					DL	-do-		
5.	27-5-71	Bullock (Dark grey)	Transverse	Three 4 mm thick	PM	Passed with a little difficulty.	..	Pins got bent when the animal bare weight on the limb. Marrow came out when the third pin was being driven.
					DM	Passed.		
					DL	Passed.		
6.	9-8-71	Buff. calf	Transverse	Two 4 mm thick	PM	Passed through 2nd hole.	Plaster cast	Distal lateral site failed due to the obstruction caused by the two pins already driven. In this site PP cast slipped down. Slings used.
					DM	Failed, passed when angle changed.		
					DL	Failed.		
7.	26-8-71	Buff. calf	Oblique	Two 4 mm thick	PM	Passed.	Modified Thomas splint	No bending of pins was noticed even on the second day.
					DL	Passed.		

Buff.calf = Buffalo calf; PM = Proximal Medial; DM = Distal Medial; DL = Distal Lateral; PP cast = Plaster of Paris cast.

All the animals were anaesthetised with 10% chloral hydrate given intravenously.

there. Therefore, distal medial and distal lateral sites were taken for driving the Rush pins in experimental animals and proximal medial and proximal lateral sites were reserved for the times of necessity.

As the pins were pliable (trial No.2) and as the increase in the number of pins (trial No.3) and in number of thick pins (trials 4 & 5) did not increase the strength of immobilisation, external splints to aid the Rush pins were tried. The plaster cast in trial six did not immobilise the stifle joint. Moreover it slipped down. The Thomas splint in trial seven prevented the bending of the pins. Therefore it was decided to try a Thomas splint. But because of the drawbacks of the full length Thomas splint given under review of literature a short Thomas splint similar to one tried by Dr. S.V. Rao on a hamstrung buffalo heifer (1971) and described under "Methods" was taken for supplementation.

SPLINTING:

The ring of the short Thomas splint was padded with tow bandaged tightly just sufficient to make the lower part of the upper extremity of tibia fit snugly into it (Fig. 8). The wall of the toes of claws of the fractured limb were drilled through and the ends of a four inch long wire were passed from before backwards through these holes. The limb was passed through the padded ring until the latter reached the region just below the tibial crest and rested on it. Then the foot was pulled down and the toe wires were fixed to the stirrup curve by twisting. Finally the limb was immobilised by bandages applied to the rods of its frame in the form of straps above and below the hock and fetlock joints to keep them semiflexed.

EXPERIMENTS AND RESULTS

EXPERIMENTS AND RESULTS

Each animal was weighed and prepared by starving and withholding water for 24 hours, washing the left limb, shaving and disinfecting the fracturing and pinning sites and anaesthetising with chloral hydrate. Next it was kept in left lateral recumbency, tibia fractured, reduction affected, medial pins inserted, side changed without disturbing the reduction splint and lateral pins inserted. Finally tarsal or tibial splint was applied and the animal kept under restraint and observation till the next morning.

After 24 hours it was allowed to move about and assisted to get up from recumbency whenever necessary. On the third day, it was let off to graze in the nearby pasture.

Radiographs were taken before and after pinning until correct pinning was done, at weekly intervals in the earlier experiments and at fortnightly intervals in the later experiments.

Antibiotics were given for five to seven days from the day of the operation, and complications treated as and when encountered.

Splints and pins were removed after variable periods. To remove the pin, the skin was tensed by pressing on the sides of the hook, incision made on the bulge until the hook was exposed, a loop of wire was passed into the hook and twisted, turned round the cutting pliers and the latter hammered until the pin came out.

Ten buffalo calves and bulls purchased for the purpose and two clinical cases - one heifer and one cow - were experimented on and the results given in Tables 5 and 6.

DISCUSSION

DISCUSSION

The results of the immobilisation of tibial fractures with Rush pins aided by a short Thomas splint have been discussed under anaesthesia, reduction, pins, drill opening, pinning sites, positioning, pinning, fracture-immobilisation-alignment, supplementation, corrections, complications, encapsulation-rejection-breakage, medication, Walker's pin and plaster cast.

ANAESTHESIA:

Workers like Kendrick (1951) and Ganis (1952) used a mixture of intravenous anaesthetics. But seasoned workers like Guard (1953) depended only on chloral hydrate general anaesthesia supplemented by fracture-site analgesia. As the mixture of intravenous anaesthetics make the assessment of anaesthesia a bit difficult, chloral hydrate only was used intravenously for inducing general anaesthesia in this project. However, anaesthesia was not maintained in all the cases.

In all the animals, except in six, eleven and twelve, first plane of surgical anaesthesia was induced. They were unconscious when the bone was fractured, but regained their consciousness partly (deep narcosis) by the time the pinning was started, as some time, between induction of anaesthesia and pinning, was consumed for fracturing and radiography. Nevertheless, they remained unmindful of the pinning operations except moving a little now and then.

Animal six, as a result of injection of a few more milliliters of chloral hydrate solution, went into second plane of surgical anaesthesia. Regurgitation of ruminal contents occurred. They were allowed to flow down the mouth by keeping the head in a slanting position. The animal was not only unconscious throughout the operation but also quiet in the post-operative period for about six hours. Therefore, this was adopted for animals eleven and twelve used for trying the finalised technique of Rush pinning. But first plane is enough for clinical cases as was done in animals four and seven because in them the radiographs will be taken before the induction of anaesthesia and no time will be lost between it and the pinning. No disadvantage was felt even when the anaesthesia lightened to deep narcosis at the time of pinning. Kendrick (1949) did tibial pinning under chloral hydrate narcosis only.

REDUCTION:

Indirect reduction was resorted to in all animals as anaesthesia induced, produced complete relaxation of muscles.

In experiments five, seven, eight and nine, animals being large in size, a reduction splint fitted with a traction device was used for extension and counter extension (Fig.10) and local manipulation for alignment of the ends of the fracture. In experiment four reduction splint without traction device was used. In experiments one, two, three, six, ten, eleven and twelve, animals being small in size, reduction was effected by the old method of applying traction on the fractured limb with ropes tied to the pastern and passed through the groins, and manipulating the fracture site.

Proper alignment of fractured ends appears to be very essential for the passage of the pin from one fragment into another. In all animals except in three, five and eleven the pins came out of fracture site. Radiographs revealed improper alignment. In animal eight, the pin did not pass the fracture site until proper alignment was effected. This was due to the internal edge of the end of the fractured fragment in the lumen of the medullary canal obstructing the pin tip during its passage. Such a thing did not occur when proper alignment was effected.

PINS:

Company pins were tried first in seven animals used for establishing the preliminary pinning procedures and in experiment seven. Failures were met with in trials one and two. Close examination revealed a defective tip in those pins. It did not curve like the sledge-runner. Therefore, its edge got into the groove of the fracture line and the pin stopped moving. In animal one, it even came out of the medullary canal through the fracture site. The pin passed the fracture site when the anteriorly directed edge of its tip was made to direct upwards by rasping it a little.

Failure in animal seven, appears to be due to the pin not bending when it was driven against the opposite wall of the medullary canal. It went in when the tip was slightly bent and redriven. This raised the doubt whether the company pins were of 18/8 SMo stainless steel which was malleable. Moreover, company pins said to have been made of 18/8 stainless steel, weighed more than those prepared from stainless steel rods got from a Madras trader who advertised the availability of 18/8 S.S. rods for sale.

In view of the defective tip, less malleability, more weight, higher cost and non-availability of exact sizes required for the individual bones, the use of company pins was discontinued for the time being, and pins made from the S.S. rods got from the Madras trader were used in the latter experiments.

Company pins were used in animals one and five. Pins made in the department were used in animals two, three, six, eight, nine, ten, eleven and twelve. Both were used in animals four and seven. Corrosion on and rejection of the pins are given in Table 8.

DRILL OPENING:

In animals three, six, eleven and twelve drill opening being very oblique the pin tip after touching the opposite wall of the medullary canal got slightly bent and on further hammering glided along its wall bending like a bow, reached the other extremity and entered the cancellous bone (Fig. 3). In animals four and eight it was less oblique. So the tip became more bent and the pin more curved. The tip could not reach the other extremity due to shortage caused by the excessive curving. In animal two the opening was least oblique. So, the pin not only became more curved but also pierced the cortex a little below the other extremity. These experiments stress the need of a very oblique opening in the bone for the pin to be driven.

In animal nine the pin pierced the opposite cortex immediately after entering the medullary canal. This might have been due to the bit of the electric drill striking the opposite cortex violently and making a bed on it, into which the pin tip might have entered during pinning and pierced the cortex when hammered. Therefore, controlled drilling was tried in the subsequent experiments to avoid such beds. In animals four and seven small sized bit was used with the idea of giving the pin a firm hold in the bone. But this resulted in splinters and cracks in the bone. Therefore, in subsequent operations bits of the same size as the pins were used for making the drill openings.

PINNING SITES:

They were one inch below the proximal extremity and one inch above the distal extremity on the lateral and medial aspects.

Sites for pinning were not opened in animal one. Bone was drilled through the skin. Consequently pin hooks could not be burried. They remained out. In course of time they themselves got burried. This was avoided in the subsequent experiments by incising the skin and subcutaneous structures and retracting them before making an opening in the bone and burrying the hooks under the skin after the pin had been driven into the medullary canal.

Proximal lateral site is a little below the lateral condyle of tibia. Peroneal nerve is coursing down this site (Fig. 1A). It was used in animal four. The muscles could not be retracted effectively. Drill pin slipped several times before making a bed due to the concavity of the lateral surface of the bone here. Two holes made in the bone could not be traced after the removal of the drill bit, for the introduction of the pin, as the muscles covered it. Bone was drilled again to pass the pin. Moreover, the hole could not be made obliquely in this site due to the bony bulge formed of the lateral condyle of tibia and femur preventing the drill pin from making the required acute angle with the bone. Consequently the pin driven in this site became more curved and short and reached the cortex above the distal extremity.

Proximal medial site is on the medial aspect of and a little below the anterior tuberosity of tibia. It was used in animal three. The pin hole could not be made obliquely due to the same causes given above. Moreover, the drill could not be worked satisfactorily and the pin could not be hammered effectively for want of working space, due to the abdomen, the pelvis and the thigh of the upper limb (even though the limb was drawn forwards) coming in the way of the drill and hammer respectively.

Distal lateral site was used in animal three. The bulge of the lateral malleolus prevented the drilling-pin from making an acute angle with the bone necessary for making an oblique opening. As a result of this, the pin driven in this site also became more curved and shorter. Moreover, external saphena vein is in this site. Therefore, distal posterolateral site was tried in animal five and resorted to in animals six, seven, eight, nine, ten, eleven and twelve. This is the best site. Moreover, in case of sepsis it has the advantage of free drainage through a dependent opening.

Distal medial site was used in animals three, four, five, six, seven, eight, nine, ten and twelve. In them, due to bulge of the medial malleolus, very oblique opening could not be drilled easily. Therefore, anteromedial site was tried in animal eleven. But it did not have any advantage over the medial site. Moreover, in the former the drilling-pin slipped several times due to the slope. Further it has also the advantage of drainage for septic fluids as in the distal lateral site. Therefore, it has been decided to use medial site only.

POSITIONING:

The medial sites were drilled and pinned keeping the animal on the side of the fractured limb. The lateral sites were drilled and pins were driven, keeping the animal on the side of the sound limb. The fractured bone was kept on a suitable wooden block enveloped in a sterile drape during drilling and pinning. Turning of the animal from side to side (of course it was turned gently and carefully) appears to have not affected the pin already fixed probably due to the presence of the reduction splint in position.

PINNING:

In animal three, three pins were used (Fig. 7A). The first two pins interfered with the introduction of the third pin. Moreover, the third pin could not have the bow shaped curve towards lateral aspect necessary for the spring action and the "three point hold" on the bone which are essential for effective immobilisation. Bending medially of the fracture site in about a week due to muscular contraction proved this. Bone marrow came out as the third pin was being driven in trials three, four and five and the experiment three. This did not happen with two pins. This shows that the fewer the number of pins driven the lesser will be the destruction of bone marrow. Moreover, in cases of immobilisation with Rush pins where the medullary canal is not completely impacted with pins, the medullary callus (sealing and uniting callus) may form to some extent which is out of question in cases of immobilisation with other medullary pins which impact the medullary canal completely at the fracture site. Therefore only two pins of suitable sizes were used in subsequent cases.

In most of the cases the pin was obstructed during its passage into the medullary canal. In animal one slight withdrawal and rotation of the pin to a side overcame the obstruction. In animal six increasing the obliquity of the drill opening allowed the pin to pass easily. In animals ten, eleven and twelve bending the fracture site upwards or downwards as the case may be facilitated its onward movement. In animal eight, correcting the alignment of the fractured ends made the pin pass smoothly up the medullary canal. In trial four, pin passed when it was bent at the tip.

In animals six, eleven and twelve (Fig. 5A,B & C) both the pins were bent like bows with points and hooks directed to one side. Such pins only have "the three point hold" and spring action. Bohlers (1955) stated that intramedullary pins would not be "satisfactorily effective" in maintaining the alignment due to the fact that superior and inferior extremities of bone are of greater diameter than the shaft. But this is not the case with Rush intramedullary pins as their points and hooks occupy the peripheral areas of the extremities. Uneventful recovery in these three animals showed that the pins were driven correctly.

In animal six, pins were side by side and against each other in the middle of the shaft due to the narrow medullary canal. In animals eleven and twelve they crossed each other a little below and above the middle due to the wide medullary canal. According to Annis (1969) contact or crossing of pins create areas of different oxygen potentials and act as anodes and cathodes and result in corrosion. The pins in these animals also showed small areas of corrosion at these points.

FRACTURE - ALIGNMENTS - IMMOBILISATION:

In no animal the fracture was exactly transverse (Figs. 4,5,6 & 7). In animal one it was nearly transverse (slightly oblique). In animals three, six, nine and eleven they were oblique. In animals two, five and twelve they were very oblique. The fractures in five and twelve extended to the lower extremity. In animal four it was not only very oblique but also very irregular. In animals eight and ten they were spiral and irregular. In animal seven it was comminuted.

All the fractures were not reduced correctly or completely. Reduction made correctly in a few cases were not maintained during the period between pinning and fixing the pins. Therefore, they got disturbed.

The fractured ends were in apposition in animals three, six, eight and twelve. In animals one and two they were facing each other, but not in apposition, probably for want of "contact compression". In animal one, the fractured ends were slightly displaced due to the third pin coming out of the fracture site. In animal four, they could not be brought into alignment probably due to improper reduction. In animal five, alignment brought about by distal medial pin was nullified first by proximal medial pin passing downwards into the lower extremity, next by distal lateral pin passing into the medullary canal through the fracture site. In animal seven, alignment of fractured fragments and bone pieces was almost brought about by reduction, but could not be maintained as the correct pinning could not be done due to the pins either coming out of or entering through the fracture site and causing cracks in the fractured ends. In animal nine the alignment brought about by reduction and immobilised by distal posterolateral pin was disturbed by the distal medial pin coming out of the fracture site. This was removed and redriven without correcting the displaced fragments. Consequently the pin entered the medullary canal through the fracture site and bent the first pin. Therefore the pins were removed and unpadded plaster cast was tried. In animal ten alignment of fractured ends was not brought about. Moreover, the pins did not take the correct bends at the outset. Pins also were not fixed proximally and distally. This might have adversely affected the immobilisation. In animal eleven, the fractured ends were almost in apposition in the radiograph taken before fixing the pins. But they were slightly displaced in the radiograph taken after fixing the pins. This might be due to not maintaining the alignment of fractured ends at the time of fixing the hooks.

In all the nine pinned animals kept under observation, except in eight and twelve the pins maintained the fractured ends, whether brought into apposition or not, in the same position until the callus formed. In animal eight, the fractured ends were in apposition at the time of pinning. The radiograph after fixing the pins was not taken. Pinning was done through the holes made in the distal extremity in the usual sites. After two weeks the distal medial pin was seen passing through the fracture site. The author thinks that the part of the bone containing the distal medial pin might have given way by the violence caused by hammering the distal lateral pin. The blows used to fix the distal lateral pin might have pushed the upper fragment medially and with it the distal medial pin. This might have chipped off the bone anchoring the hook of the distal medial pin. In animal twelve, the ends were in apposition at the time of pinning. After three weeks, lateral displacement was detected. This might be due to non-fixation of the point of distal medial pin in the proximal extremity.

From the above findings it can be concluded that the Rush pins when passed correctly and fixed effectively can immobilise the fracture. The callus was normal when the fractured ends were in apposition and abnormal when they were not in apposition.

SUPPLEMENTATION:

In the treatment of tibial fractures in large animals, they being very heavy, most of the workers adopted methods which can be clearly divided, as in

Table 7, into two parts, one for immobilisation of fractured ends and the other for taking the strain that was formerly borne by the bone. However, there were workers who appeared to have depended only on one, for both the purposes, for example, Ganis (1952) on transfixing pins, Hickman (1957) on bone plates, Mohanty (1970) on modified Thomas splint and Gill (1970) on plaster of Paris coaptation. But intramedullary Rush pins in this project, being very weak, short modified Thomas splints were used and named as Tarsal and Tibial splints as the former was intended for metatarsus and the latter for tibia.

In animal three, the short Thomas splint extended from the tibial crest and condyles to a little beyond the foot. It was bent at the level of the hock to keep the hock and fetlock in a semiflexed condition as suggested by Bohler, 1936 (cited by O'Conner, 1950) and Reichel (1956). By the third day a swelling appeared down the limb due to the pressure of the ring on the saphena vein, and pressure sores appeared round the upper extremity of tibia and on the sides of hock and fetlock due to the ring pressing below the tibial crest and condyles and the frame on the sides of joints. Moreover, the stifle was not immobilised. Therefore, another splint (Fig. 8) extending upto stifle and resting

TABLE 7 - FRACTURE TREATMENT

o.	Author	Year	Immobilisation	Supplementation
1.	Thomas	1939	Iron plate and wooden board	Modified Thomas splint
2.	Gish	1941	Wooden board	-do-
3.	Alstan	1942	Baling wire	Brace
4.	Guard	1953	Bandages and tapes	Modified Thomas splint
5.	Kindrick	1951	Plaster cast	Plaster cast and pin rods.
			(Pins were used for	anchoring the cast)
6.	Singh & Rao	1954	External pins. Bone plates. Intramedullary pin.	Unpadded plaster of Paris cast.
7.	Reichel	1956	Transfixing pins	Plaster of Paris cast and iron plates
8.	Beckenhauer	1958	Plaster cast	Detachable modified Thomas splint
9.	Lundvall	1960	Stainless steel plates Bone plates Transfixing pins	Plaster cast Plaster cast External bars and plaster cast
0.	Robert	1960	Transfixing welding rods	Iron splint and plaste bandage.
1.	Bower & Webb	1963	Transfixing Steinmann pins	Aluminium plates
2.	Springstead	1969	Plaster cast	Modified Thomas splint
3.	Mohanty	1970	Transfixation	Plaster cast

on the straight ligaments and patella, with a wider ring, chambered behind the medial fixture for the saphena vein (Fig. 2A) and widened at the joints was used. This caused negligible damage. In animal ten, peroneal paralysis supervened probably due to the ring or hook of the frame of the displaced splint pressing on the nerve above the lateral condyle of tibia. Therefore,the ring was chambered at and behind the lateral fixture also in experiments eleven and twelve.

In experiments nine and ten posterior part of the ring was bent upwards to give it further support, as in the earlier cases the ring had only anterior support. This bend in animal nine caused a pressure sore probably due to the hardening of the padding of the ring brought about by the animal wallowing in the neighbouring pond. Therefore, in animals eleven and twelve this type of upward bend of the ring was avoided.

The splints helped the animals in ambulation. All the animals except seven were able, from the third day, to go to the pasture in front of the department. Animals with tarsal splints walked normally and those with tibial splint first dragged the splint during progression and later used for ambulation. After a month they were able to walk even without the splint confirming the statement of Reichel (1956) that there was no better after-treatment than the free active movement of the animal.

Slings made of ropes, cot and gunny bags were used for trial animal six and experimental animal seven. The animals made no effort to stand on the functionally sound limbs but depended entirely on the sling for support as noted by Beckenhauer (1958).

CORRECTION:

In animals three and four, even after immobilisation with Rush pins, the distal fragment deviated medially. This was corrected as was done by Thomas (1939) and Gish (1941) by placing a padded 3"x6" board between the fracture site and medial rod of the splint and bandaging the part. In animal four, due to neglect of the owner it slipped out whereas in animal three it remained in position until the callus formed. But it caused a pressure sore exposing the bone. It healed in no time without any complication or deformity.

COMPLICATIONS:

In animal two, osteoperiostitis due to hammering the pin points piercing the cortex against the bone, appeared making its cannon voluminous and hot. In animal ten, abscesses developed at the lower extremity probably due to neglect of aseptic routine. It was opened and the pus was drained. Draining sinuses were present in animals three and eight. In animal three pressure sores appeared below the tibial crest and condyles and on the hock and fetlock joints. In animal six negligible pressure sores appeared round the stifle and below the patella. In animals nine and ten it appeared behind the thigh. In animal seven, even though amputation was done properly, radial paralysis resulting from the compression of the nerve between the thorax and the shoulder blade during prolonged recumbency on the hard table for the operations, made the case hopeless. In animal ten, peroneal paralysis supervened. Animal twelve suddenly became sick and died. Post-mortem examination revealed acute gastritis. However, all the complications were attended to, and prevented in subsequent experiments.

ENCAPSULATION - REJECTION - BREAKAGE:

Distal lateral pin hook in animal three at the time of removal was seen covered by a thick connective tissue. This might be encapsulation. In animal eleven, distal anteromedial hook could not be detected probably due to bony encapsulation as written by Annis (1969).

Rejection of pins could not be detected in time as it was not thought of at the outset. However, a few cases of rejection were met with such as partial rejection, total rejection, rejection due to mechanical irritation, infection, corrosion etc.

The proximal medial pin in animal three showed signs of early stage of rejection. There was a fluctuating tender swelling on its hook. Pus drained out when it was opened. Distal medial pins in animals three and four appeared to be cases of partial rejection. There were draining fistulae. Later they were fly blown. So the pins were removed. Distal lateral pin in animal eight seems to be an example of total rejection as it was extruded. Pins in animal ten appears to be examples of rejection due to infection. So they were removed. No case of rejection due to corrosion was met with. It was too early to come across them as only extensive corrosion leads to rejection.

Small patches of corrosion were detected after the removal of the pins. They were in the form of dark patches on the hammer marks made during its making in pins removed from animals two and three, and rusty patches at the contact points in pins removed from animals six and eleven.

No cases of breakage nor bending were met with, evidently due to modified Thomas splint taking all the strain. The sum and substance is given in Table 8.

TABLE 8 - ENCAPSULATION, REJECTION AND BREAKAGE

No.	Experiments	1	2	3	4	5	6	7	8	9	10	11	12
1.	Variety of pin	C	D	D	CD	C	D	CD	D	D	D	D	D
2.	Encapsulation	..	..	+	..	..	..	..	..	..	..	+	..
3.	Corrosion	..	+	+	..	..	+	..	..	..	..	+	..
4.	Partial rejection	..	..	+	..	..	..	..	..	+	+	..	..
5.	Total rejection	..	..	..	..	..	..	..	+	..	..	..	..
6.	Fracture of pin	----------- Nil -----------											
7.	Bending	----------- Nil -----------											

C = Company make

D = Departmental make

MEDICATION:

In all animals except in four and eleven Streptopenicillin was used for seven days. In animal four Terramycin was used for five days and in animal eleven Omnamycin was used for five days. In experiment nine very heavy doses were given for the first four days as the pins were driven and withdrawn twice, and in the last stage of the operation the aseptic routine was not perfect. Glucose saline was injected just to overcome dehydration in animals one and two and to tone up the system in animal seven.

WALKER'S PIN VERSUS RUSH PIN:

Walker's pin was taken for trials as it had projecting leaves on its sides to prevent rotation of the lower fragment of the fractured bone. But it showed all the disadvantages of Steinmann's pin. Moreover, it is weaker than Steinmann pin. Walker himself admitted later (1971) that it lacked strength.

On the other hand Rush pins, in addition to the twelve advantages listed under introduction appear to have some more points in their favour.

1. They can immobilise all sorts of fractures if reduced properly.

2. Strength of immobilisation can be increased and bending at the fracture site can be minimised by using thicker pins or increasing the number of pins in the medullary canal to the impacting point.

3. Grip of the Rush pin on the bone is more than that of Walker's pin or Steinmann's pin as the hooked end of the former is fixed in the cortical bone of the shaft, where as both ends of the latter two are fixed in cancellous bone of the extremities.

4. They destroy less bone marrow as they are lesser in diameter and pass along the sides of the medullary canal.

5. There is a possibility of formation of endosteal callus due to space between the cortex and medullary pins.

PLASTER CAST VERSUS RUSH PIN:

The method adopted by Springstead (1969), as it gave encouraging results, was tried with a little modification in animal nine, a case of oblique fracture of tibia. In this case the plaster of Paris cast was applied in three stages and anchored to the tibial splint (Figs. 6A & B). In the first stage it was applied to the medially deviated proximal fragment and outer rod; in the second stage to the laterally deviated distal fragment and medial rod until the ends were brought into apposition; in the third stage it was applied all around until the plaster was thick enough to bear the weight. A little displacement of the ends of the fragments was detected in the third week-end radiograph. This sort of displacement did not occur even in cases of great oblique fractures immobilised with Rush pins. This shows that immobilisation with Rush pins driven and fixed properly after proper reduction is absolute, where as immobilisation effected with only plaster cast is uncertain.

SUMMARY AND CONCLUSIONS

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The simple anaesthetic methods - sciatic nerve block, epidural block, intravenous anaesthesia - were tried on six animals and chloral hydrate anaesthesia was adopted for both trials and experiments with Walker's pin and Rush pins. Various fracturing methods - striking with an iron pipe, hammering the iron rod, angular iron or chisel kept on the part - were tried on four animals and fracturing with chisel and hammer was taken for use in both trials and experiments. Walker's pin was tried on three animals and abondoned as it was weaker and had all the disadvantages of cylindrical intramedullary pins.

Rush pins were tried on seven animals to know the suitable pinning sites, number and thickness of pins required and whether they can bear the weight of the animal. Next, bearing in mind the experiences gained in the trials, they were applied on twelve animals, two with metatarsal fractures and ten with tibial fractures including two clinical cases. In one animal only plaster of Paris cast was applied. All the animals except one were kept under observation. In one case limb was amputated. One developed peroneal paralysis. Nine animals walked normally.

The following conclusions are drawn from the above cited trials and experiments.

1. Plane I of surgical anaesthesia is enough for immobilisation of tibial fractures with Rush pins.

2. The pinning sites on the distal extremity are better than those of proximal extremity. Postero-lateral and medial sites are the best as there is plenty of working space for drilling and hammering and as they facilitate free drainage in case of sepsis.

3. Drill bit used for making the opening must be of the same size as that of the pin. It should not be allowed to strike the opposite cortex.

4. Perfect reduction of the fracture, correct alignment of the fractured ends, pins with malleable temper and sledge runner tip, and very oblique drill opening in the bone are very essential for smooth pinning.

5. Pins should not be driven from the opposite extremities, especially on the same side, as the second pin nullifies the immobilising effect of the first pin. Immobilising effect will be there only when the points and hooks are fixed (anchored) in the bone.

6. Two pins are enough for immobilisation of the

fractured ends if driven like bows crossing each other and fixed in three places. But a short Thomas splint is necessary to give support to the pins until the time of callus formation.

7. Rush pins made of 3 mm, 4 mm or 5 mm thick 18/8 SMo stainless steel and tibial splint made of 1/4", 3/8", 1/2" or 5/8" thick iron rod should be used depending on the size and weight of the animal. Stainless steel rods one inch less than the length of the bone and iron rods 3½ times longer than the limb from stifle to foot are sufficient to make the Rush pins and tibial splints respectively.

8. All sorts of fractures and of various situations can be immobilised with Rush pins if the ends are brought into accurate apposition.

9. In spite of rigid aseptic routine, antibiotics for seven days are essential.

10. In young bovines below two hundred lbs body weight splint may be removed after four weeks and pins after eight weeks as the former causes pressure sores and the latter electrolysis at their junction or contact points.

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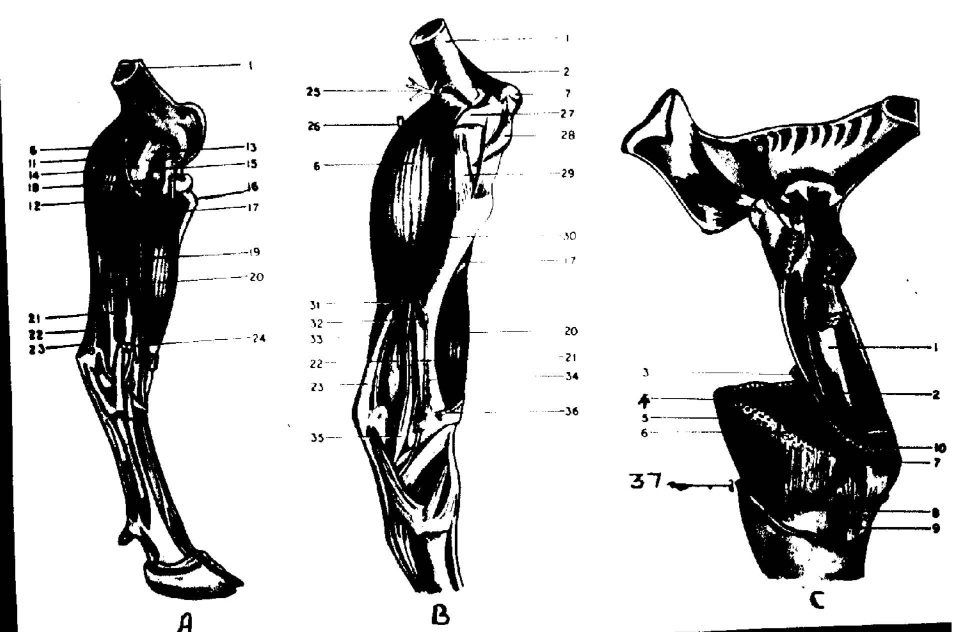
APPENDIX

1 A. Muscles of the leg of the right hind limb (Anterolateral aspect)

B. Muscles of the leg (Posterointernal aspect)

C. Muscles behind the stifle (Deeper dissection - Anterolateral aspect)

1. Femur; 2. Articularis genu; 3. Adductor; 4. Semimembranosus; 5. Semitendinosus; 6. Gastrocnemius; 7. Patella; 8. Middle patellar ligament; 9. Lateral patellar ligament; 10. Vastus externus; 11. Peroneal nerve; 12. Soleus; 13. Lateral femoro-tibial ligament; 14. Posterior femoro-tibial ligament; 15. Semilunar cartilage; 16. Anterior tuberosity of tibia; 17. Tibialis anterior; 18. Peroneus longus; 19. Lateral digital extensor; 20. Complex muscle; 21. Deep digital flexor; 22. Tibial aponeurosis; 23. Tendon of the superficial flexor; 24. Superficial peroneal nerve; 25. Femoro-popliteal vessels; 26. Tibial nerve; 27. Medial femoro-patellar ligament; 28. Medial patellar ligament; 29. Medial femoro-tibial ligament; 30. Popliteus; 31. Superficial digital flexor; 32. Long head of the deep digital flexor; 33. Tendon of gastrocnemius; 34. Tibia; 35. Tendon of the deep digital flexor; 36. Anterior annular ligament; 37. Ring of the tibial splint.



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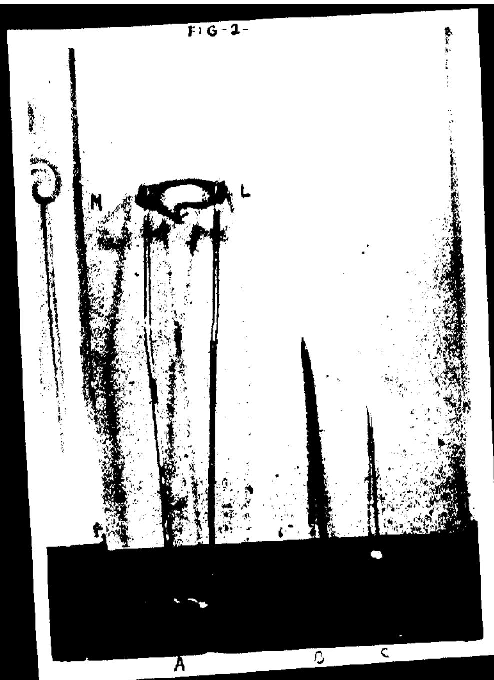
2 A. Tibial splint; B. Walker's pin; C. Rush pin

3. Sagittal section of tibia showing the sled-runner point guiding the pin along the wall of the medullary canal.



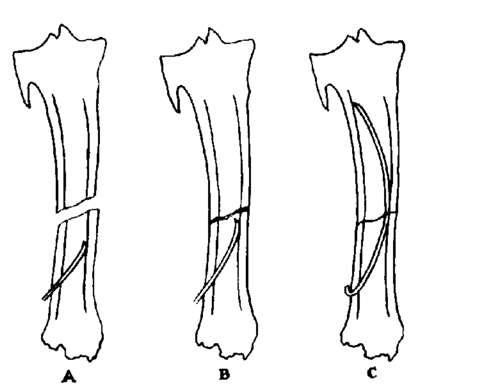
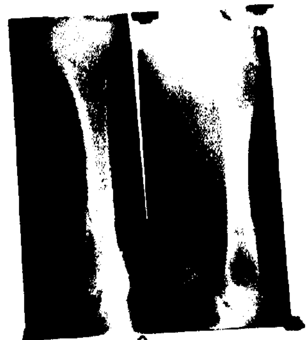


Fig: 3 . SAGITTAL SECTION OF TIBIA SHOWING THE SLED-RUNNER POINT GUIDING THE PIN ALONG THE WALL OF THE MEDULLARY CANAL

4 A. Spiral fracture (Animal No.8)

B. Comminuted fracture (Animal No.7)

C. Irregular and oblique fracture
(Animal No.10)



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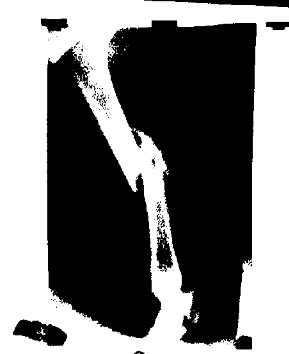

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5. Immobilisation with two Rush pins

A. Animal No.12; B. Animal No.11; C. Animal No.6

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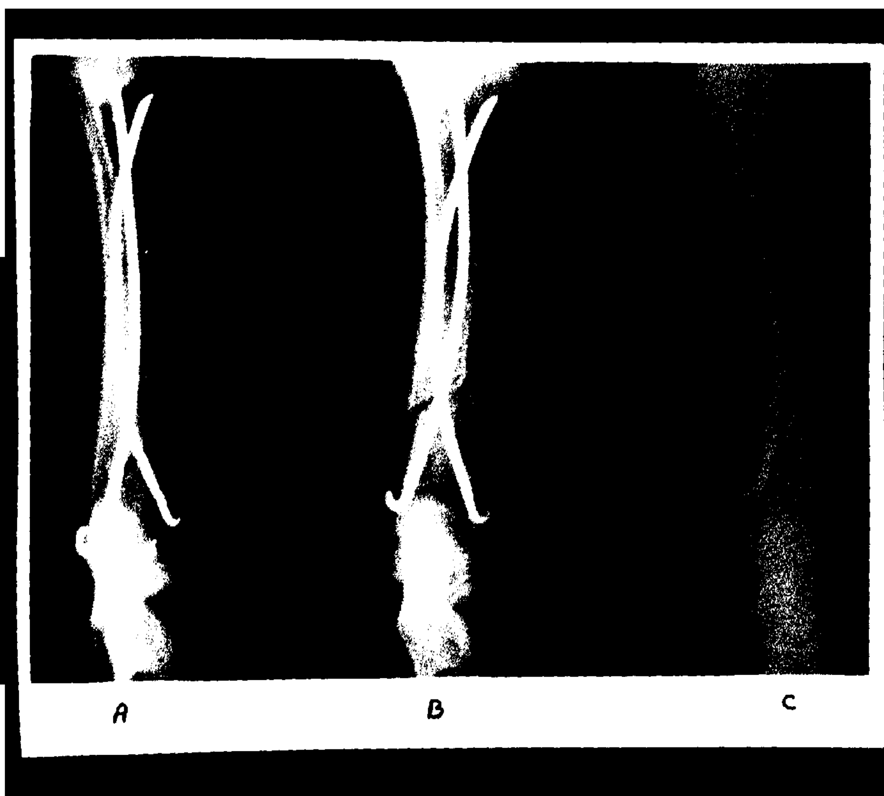

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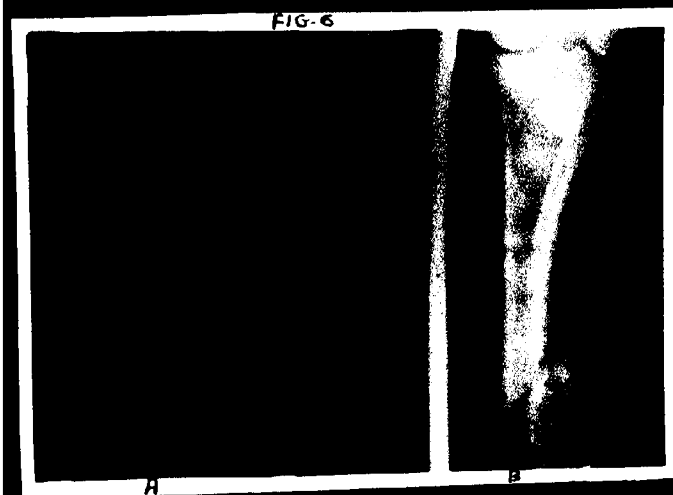
6. Immobilisation with plaster of Paris cast

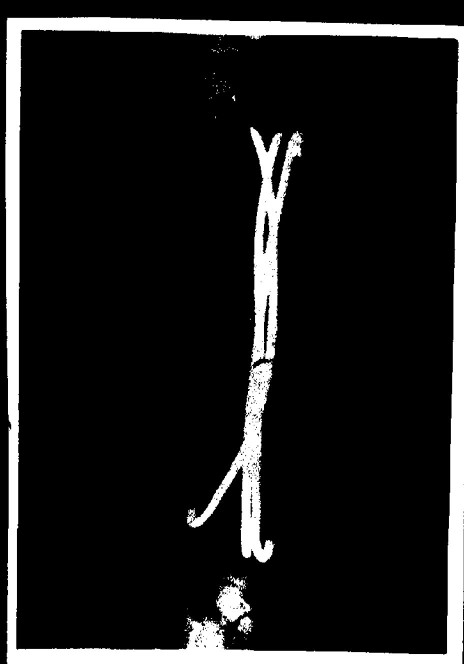
A. Fracture ends at the time of application of plaster cast

B. after two weeks (Animal No.9)

7. Immobilisation with three Rush pins (Animal No.3)

FIG-6





8. Immobilisation with Rush pins and tibial splint
(Animal No.3)

9. Immobilisation with plaster cast and tibial splint
(Animal No.9)

10. Traction splint.