

TREATMENT OF FRACTURE OF METACARPUS IN CALVES USING AUTOGENOUS RIB GRAFT

By

SYAM K. VENUGOPAL

THESIS

Submitted in partial fulfilment of the
requirement for the degree

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Faculty of Veterinary and Animal Sciences
Kerala Agricultural University

Department of Surgery
COLLEGE OF VETERINARY AND ANIMAL SCIENCES
Mannuthy Thrissur

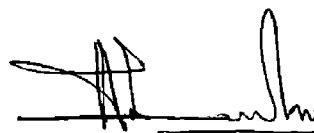
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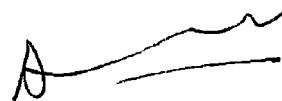
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Mannuthy

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Dr A M. JALALUDDIN
Chairman Advisory Committee
Professor
Department of Surgery
College of Veterinary & Animal
Sciences Mannuthy

CERTIFICATE


We the undersigned members of the Advisory Committee of Dr SYAM K VENUGOPAL a candidate for the degree of Master of Veterinary Science in Surgery agree that the thesis entitled TREATMENT OF FRACTURE OF METACARPUS IN CALVES USING AUTOGENOUS RIB GRAFT may be submitted by Dr SYAM K VENUGOPAL in partial fulfilment of the requirement for the degree



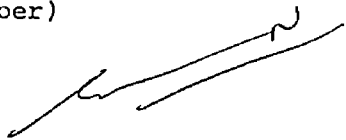
Dr A M JALALUDDIN
Chairman Advisory Committee
Professor
Department of Surgery
College of Veterinary & Animal Sciences
Mannuthy



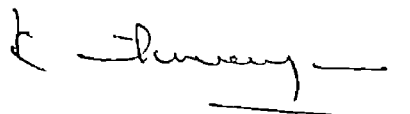
Dr S RAVINDRAN NAYAR
Professor
Department of Surgery
College of Veterinary
& Animal Sciences
Mannuthy
(Member)



Dr K N MURALEEDHARAN NAYAR
Professor
Department of Surgery
College of Veterinary
& Animal Sciences,
Mannuthy
(Member)



Dr N GOPAKUMAR
Associate Professor
Department of Pharmacology
and Toxicology
College of Veterinary
& Animal Sciences
Mannuthy
(Member)



EXTERNAL EXAMINER

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Dr SYAM K VENUGOPAL

*Dedicated to the
fond memory of
my beloved mother*

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Introduction

INTRODUCTION

treatment of fracture of long bones in large animals had always been a problem to the veterinary practitioner. Heavy weight of the body prolonged recumbency resulting in decubitus ulcers, high cost of treatment, reduction of its utility and difficulties encountered in the rehabilitation of the animal are the major hurdles which the veterinarians have to face while treating fractures of long bones in large animals.

According to Tulleners (1986) and Denny et al (1988) metacarpal or metatarsal fractures were most common in cattle due to their peculiar anatomic disposition. Patil et al (1991) reported that the incidence of metacarpal fracture in bovine (16.4%) was next to tibial fracture (27.3%) and regardless of species fracture of shaft of long bones was higher.

The outcome of treatment of fracture depends to a great extent on the exact diagnosis of the fracture, timely immobilization and satisfactory maintenance of apposition of the fragments. According to Kirk (1952) and Lundvall (1960) virtually every form of treatment can be applied with varying degree of success in animals. The fracture of the metacarpal bone could be treated with external or internal immobilization methods.

Bone grafting was reported to hasten healing of fractures in animals (Whittick 1975) Bone grafting using autogenous bone grafts in combination with intramedullary pins (Coleman 1956) heterogenous bony intramedullary sliding pegs along with metallic intramedullary pins (Singh et al 1973) bone plates and screws prepared from macerated buffalo bone (Bommaiah et al 1976) homogenous onlay and inlay bone grafts (Khan and Ahmed 1977) autogenous onlay rib grafts (Sahu and Baghel 1978) allogenic cortical onlay bone plates (Pao et al 1985) and heterogenous bone plates and stainless steel neutralization plates (Moulvi et al 1986) had been reported in *animals*

On screening the available literature reports on detailed experimental study using autogenous rib grafts in the treatment of fracture of metacarpus in calves was found to be scarce Hence the present study was undertaken in calves with the following objectives

- 1 To assess the efficacy of autogenous rib grafts for immobilization of fracture of metacarpus
- 2 To assess the acceptability of the grafts and
- 3 To compare healing of fracture of metacarpus with autogenous rib grafts and plaster of paris cast with that of external immobilization using plaster of paris cast alone

Review of Literature

REVIEW OF LITERATURE

Kirk (1952) reviewed various modern methods of fracture repair in small and large animals and concluded that bone plating intramedullary pinning use of bone screws and different external immobilization techniques could be used in suitable combinations in the treatment of fractures in large animals. He opined that bone grafts act both as a local reservoir of calcium and as splints and that a simple fracture with no displacement could be satisfactorily treated with plaster cast.

Coleman (1956) recommended autogenous cancellous bone grafts in combination with intramedullary pinning for the treatment of fractures of femur in dogs and reported that it prevented non union restored normal length of the bone and initiated early healing.

Hoffman (1956) recorded successful immobilization of fracture of radius in a heifer using plaster of paris bandages reinforced with splints of plywood.

Lundvall (1960) studied the efficiency of different methods of treatment adopted in 151 cases of fracture of long bones in large animals. He used plaster cast Thomas splint intramedullary pins stainless steel plates and

screws and transfixation pins with and without plaster cast. It was found that plaster cast supported with metal splints was the most satisfactory method for calves. He opined that plaster cast should extend from below the coronary band to a point preferably including the joint above the site of fracture to avoid oedema of the subcutaneous tissue along with necrosis.

Gertsen and Brinker (1969) used bone plates for immobilization of fracture of metatarsus in ponies and suggested the same for fracture of metacarpus. They also stressed the necessity for simultaneous use of a good cast and opined that the time of removal of the cast should be determined by radiographic examination of the healing callus.

Mohanty et al (1970) studied the treatment of fracture in 26 experimental and 40 clinical cases in cattle and found that unpadded plaster cast was satisfactory for metatarsal and metacarpal fractures. They observed that fracture treatment and healing had been better in young and light body weight animals.

Lance (1972) stated that when bone grafting was done the bulk of the bone implant died and was replaced. A single piece of fresh autograft applied to the cortical surface of the recipient site was most satisfactory.

Osteogenic potential of periosteum depended upon the inclusion of the cambium layer

Rhinelanders (1972) confirmed that vascularisation was the most sensitive indicator of the complete incorporation of a bone graft or implant by the host. Bone graft revascularisation took place first at the capillary level. Old bone canals in a cortical graft got revascularised very slowly. The cancellous bone grafts got revascularised quicker than cortical graft.

Tyagi and Gill (1972) evaluated transfixation pinning and bone plating for fracture of tibia and large metatarsal bone in two groups of calves. Transfixation was found to be useful in the treatment of oblique fractures while bone plating was satisfactory in transverse fractures. The animals in which bone plating was done were able to bear weight on the affected limb first though there was slight lameness.

Singh et al (1973) studied the healing of tibial fracture in canines using heterogenous bony intramedullary sliding pegs along with transverse bony pins and metallic intramedullary pins. The fractures treated with bony sliding pegs healed with endosteal as well as periosteal

callus and those treated with metallic pins healed mostly by periosteal callus than endosteal callus indicating that bony pegs did not destroy the vessels to the extent that intramedullary pins did. They presumed that the bony pegs provided a scaffold for the passage of the bone forming cells.

Fessler and Amstutz (1974) observed that a fracture line will be radiographically evident even if the periphery of the callus got clinically stabilized. Bony callus developed from vascular periosteum and was evident by fifth day to two weeks. Depending on the blood supply and stability of fracture repair consolidation of callus took three weeks to ten weeks.

Winstanley (1974) reviewed the treatment of fractures and stated that a fractured bone under normal circumstances heals by the production of periosteal and endosteal callus. But application of pressure to the fracture site which provided rigid fixation resulted in direct bony union with the formation of minimum periosteal callus. He has also stated that in addition to the internal fixation some form of external support should be provided for proper stability in the treatment of fractures.

Jones (1975) reviewed extensively the repair of fractures in equines by way of reduction and immobilization by various methods. He opined that the healing of fracture in compression technique is not by external callus formation but by direct or primary bone growth across the Haversian system provided the blood supply to the fracture fragments and rigidity are retained.

Singh and Nigam (1975) studied the repair of fracture of metacarpus in equines using stainless steel plates and homogenous bone plates. They opined that the external immobilization with plaster of paris cast together with the internal fixation was adequate for the prevention of rotation. Radiographically the fracture gap was visible even at the end of sixth week but there were signs of callus formation.

Whittick (1975) enumerated the process by which a bone graft hastened fracture healing. It provided rigidity induced osteogenesis by the surviving osteocytes and increased vascularisation at the transplant site. It facilitated utilization of mineral and matrix ingredients of the transplant bone. Host reaction due to antigenic and inflammatory responses facilitated resorption and replacement of the implant with new bone.

Bommaiah et al (1976) studied the efficacy of bone plates and screws prepared from macerated buffalo bone for the treatment of fracture of tibia in dogs. The bone plates and screws were boiled in water for half an hour, dried at room temperature and were stored in glass bottles. They were sterilized by autoclaving along with surgical pack just before use. The bone plates, due to their inorganic content, had enough physical strength to serve as rigid internal splints. The window produced at the plaster cast was an advantage to inspect the operated site periodically. They were of the opinion that the bone plates and screws gave good results on par with metallic plate and screws. The main advantage of bone plate and screws was that they were absorbed automatically.

Braden and Brinker (1976) while evaluating bone healing in dogs reported that osteogenic layer between the cortex of the bone and the outer fibrous periosteal layer was responsible for the external callus. In case of intramedullary pinning, the formation of bone in the fracture gap depended on the crossing of the fracture gap by the medullary vessels and the movement of fragments resulted in fibrous callus by seven to fourteen days. The external callus derived its blood supply from periosteum as well as from extraosseous blood supply. The large amount of external fibrous callus stabilized the fracture gap and set

the stage for mature callus to develop. Mature callus was mostly trabecular or loosely woven bone. The bone plates when used was the most stable fixation device and the amount of external callus was less because of the stability.

Khan and Ahmed (1977) studied fresh homogenous onlay and inlay bone grafting techniques in buffalo calves. Limping of the limb persisted upto the 10th day of operation and thereafter the gait gradually became normal. The efficiency of bone grafts was determined by its ability to contribute to new bone formation, stimulate osteogenesis and its replacement by new bone. The radiographic picture of the onlay bone grafts four weeks after transplantation showed clear gap between the grafts and the host bone and after eight weeks showed indication of new bone formation. Bone formation was observed to be encroaching from the host bed to the graft indicating creeping replacement in both the techniques. No graft rejection was observed in any of the groups.

Singh (1977) evaluated the effectiveness of fresh and preserved homogenous bone grafts and metallic bone plates in fracture healing based on the clinical, roentgenological, macroscopic and histological observations. The bone defect having no implant showed better degree of new bone formation. Angiographic findings showed that

vascularisation of the cortical homogenous grafts was poor but when compared with different types of homogenous grafts the vascularisation was found to be on a decreasing scale as follows frozen fresh autoclaved and merthiolate preserved grafts In case of inadequate immobilization the increased extraosseous circulation persisted for longer duration as medullary circulation could not be re-established across the fracture gap and that resulted in delayed union with bigger external callus

Ackerman and Silverman (1978) reported that radiographic evidence of fracture healing became apparent long after clinical union and hence clinical examination was sufficient for evaluating fracture healing

Sahu and Baghel (1978) treated successfully a non united compound fracture of metacarpus in a cow using autogenous onlay rib graft coupled with skin transplantation

Singh (1978) evaluated the efficacy of simple coaptation stainless steel plating and homogenous onlay bone plating in the treatment of metatarsal fractures in buffalo calves He found mild periosteal reaction by the second week moderate periosteal reaction with bridging of

fracture gap by the fourth week, further reduction of the gap by the sixth week and almost complete obliteration of the gap by the eighth week

Singh et al (1978) conducted angiographic studies in metatarsal fractures treated with fresh and preserved allogenic bone grafts in buffalo calves. Cortical homogenous transplant was poorly penetrated by vessels from the host bed and the bone defects without implants were found to be vascularised earlier. It was concluded that penetration of the graft by blood vessels played an important role in the incorporation of grafts.

Bloom and Mentstegge (1980) reported that stable fixation caused reduced periosteal callus formation especially in the case of articular fracture or fractures in the vicinity of the joint.

Ayyappan (1981) immobilised fracture of tibia in calves with K-nails and observed that lameness persisted upto six weeks after immobilisation. He observed that the animals were able to bear weight on the operated limb 10-30 days after the operation.

Rao (1981) studied the role of allogenic bone grafts in fracture healing of metacarpus in buffalo calves. Marked periosteal callus and incomplete obliteration of the

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fracture gap were noticed in cases treated with simple coaptation. Angulation, delayed union and malunion noticed with simple coaptation were less in animals treated with stainless steel plates and allogenic bone plates. Histologically the healing callus was predominantly chondro osteoid with simple coaptation and osteoid in which bone plates were used for immobilization.

Kumar et al (1983) conducted trials with simple coaptation, K nailing and double plate fixation for the repair of tibial fracture in calves and observed that simple coaptation resulted in inadequate immobilization, prolonged lameness, angular deformity, large external callus and malunion.

Rao et al (1983) compared the effects of allogenic bone plates and metallic plates with cancellous bone grafts for repair of metacarpal fractures in calves. The allogenic bone plate provided good stabilization at the fracture site. Immobilization with simple coaptation resulted in angulation, delayed union and malunion. The use of frozen cancellous bone grafts with onlay bony or metallic bone plates resulted in better bone healing in comparison with autoclaved cancellous bone grafts.

Singh et al (1984) observed that malalignment and infection were the most common postoperative complications.

following external and internal immobilization of fracture in bovines equines and ovines External immobilization by simple coaptation hanging pin cast and transfixation were mostly complicated by malunion delayed union and non union Infection and elevation of plates were major complications of plate fixation Internal fixation with intramedullary pin K nail and double plates fixation had minimum post operative complications

Rao et al (1985) found that allogenic cortical onlay bone plates could be used as effective substitute for stainless steel plates in immobilising metacarpal fractures in young buffalo calves Simple coaptation was associated with displacement of fracture fragments and delayed union Infection and elevation of plates were the major complications encountered in internal plate fixation

Moulvi et al (1986) treated femoral fractures in goats using heterogenous bone plates prepared from adult buffalo ribs and stainless steel neutralization plates The radiographic union of fragments was discernible at four weeks when bone plates were used and by six weeks the continuity of the medullary canal was re established But in cases treated with stainless steel plates the healing process was incomplete even by six weeks

Fulleners (1986) treated metacarpal and metatarsal fractures in dairy cattle with external coaptation transfixation pins with or without plaster casts or internal fixation (plates and screws) Fracture healing was characterised radiographically by extensive circumferential periosteal new bone growths closure of distal physis and preservation of articulation adjacent to the fracture site Presence of massive external callus was useful in healing when stability after immobilization was not ideal

Denny et al (1988) reviewed management of bovine fractures and found that treating metacarpal and metatarsal fractures using compression plates was successful compared to treatment with plaster cast alone They also found that fractures of large metacarpus and metatarsus were very common in cattle and occurred with equal frequency

Binnington (1990) reported that autogenous cortical grafts were used to supplement or create internal fixation or to bridge large fracture defects where additional stabilization was needed Cortical bone grafts could be used in the form of onlay grafts inlay grafts or as peg grafts Onlay and inlay grafts were kept in position by the use of cerclage wire screws smillie nails bolts or by wedging into position He observed that a cortical bone

transplant showed radiographic evidence of healing only by four to six months with complete healing evident by one to two years after grafting

Biswas (1990) studied external immobilization techniques using plaster of paris cast transfixation pinning and gum cast in experimentally created fracture of metacarpus in calves and found that the animals could get up and lie down without assistance and were able to walk by the first week after treatment though there was favouring of the fractured limb and dragging of the toes. Histologically the callus cropped at two weeks showed periosteal and capillary proliferation adjacent to the fracture site along with zones of ossification of the callus. The callus cropped at four weeks revealed extensive ossification with trabeculae formation and areas of fibrous tissue and inflammation with transfixation pinning, whereas with simple coaptation the callus at four weeks was characterised by marked connective tissue and capillary proliferation. The callus cropped at six weeks showed interconnected ossious trabeculae and ossification of external and internal callus with transfixation pinning. Hyaline cartilage was observed in the callus in one animal. With simple coaptation the callus was characterised by zones of hyaline cartilage among areas of ossification.

Das et al (1990) in their experimental study in calves for the repair of frontal bone defect using autogenous rib grafts found that the margin between the graft and recipient site became indistinct on the 15th day. Microscopic view at 45th day showed focal union of the grafted bone with linear calcification at the juncture line. The trabeculae of the united bones had live osteocytes. Microscopic changes on the 90th day showed proliferation of capillaries and periosteal connective tissue with varying degrees of degeneration of trabeculae. The infiltration of osteoclast at some trabecular ends indicated that rejection did not occur.

Stevenson (1990) stated that, the bone graft incorporation occurs in five histologically recognisable phases viz inflammatory phase which lasted for a week followed by phases two and three characterised by revascularisation and osteoinduction which was completed within two weeks of surgery. The fourth and longest phase was characterised by osteoconduction and it lasted for several months. During the phase five the non viable non-resorbed graft material remained and functioned in a mechanical weight bearing and stress-transmitting fashion and this phase was known as mechanical phase.

Bisla et al (1991) during their evaluation of entire segment cortical bone grafting in goats reported that cortical bone grafting provided both structural strength and osteogenic property and also maintained adequate length of bone. Evidence of periosteal thickening was seen in autograft group at 15 days. The callus tissue was composed of fibrocartilage and cancellous bony trabeculae. At 30 days the callus was composed of thin walled bony trabeculae, fibrocartilage and the inter trabecular spaces were lined by osteoclasts. At 45 days the callus showed cancellous bony trabeculae and evidence of endochondral ossification. At 60 days thickening of bony trabeculae along with Haversian system was observed. At 90 days an evidence of gradual replacement of cancellous bony callus into lamellar bone with development of Haversian system was seen. Resorption of callus and neovascularisation of superficial layer of graft were also observed. They were of the opinion that fresh autograft and homograft revascularised better than autoclaved one. It was concluded that autograft and homograft were completely incorporated into callus tissue by creeping substitution and retain osteogenic property upto three months following bone grafting.

Mistry and Padkod (1991) conducted clinical and radiographic evaluation of fabricated horn plates and

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stainless steel plates in the repair of metacarpal fracture in buffalo calves. Clinically there was no difference in the healing process between the groups by 15th day. Clinical healing was observed by 30th day. External support to the fractured limb was given with bamboo splints and cotton bandages. The animals could bear weight immediately after repair with stainless steel plates whereas it took four to seven days for the animals with horn plates. Radiographs at 15 days did not reveal any sign of healing and the fracture line was discernible. The functional restoration gradually improved in all the animals of both the groups at 30 days. They could walk almost normally with a slight limp. Radiodense cuff of callus bridging the fracture fragments was observed at 30 days in both the groups but the fracture line was clearly discernible.

Patil et al (1991) reported that incidence of fracture in female animals was higher than that in males except in donkeys, camel and dogs. Among cattle 27.3 per cent of fractures were seen involving the tibia followed by metacarpus (16.4 per cent).

Ulemale and Kulkarni (1992) used allogenic bone grafts to correct diaphyseal segmental defects of metacarpus of calves and found that by 28th day there was marked proliferation of osteoblasts and chondroblasts, deposition of osteoid matrix and establishment of Haversian system.

Materials and Methods

MATERIALS AND METHODS

The experimental study was conducted on 12 apparently healthy crossbred male calves aged six to twelve months and weighing 50 to 80 kg. They were kept under observation for a period of 10 days prior to the experiment under identical conditions of feeding and management. The animals were divided into two groups viz Group A and B.

Group A - Consisting of six animals numbered serially from A/I to A/VI

A complete transverse midshaft fracture was created on the right metacarpus by open method. An eight centimeters long piece was harvested from the last rib of the same animal. Two rib grafts were prepared from the harvested rib and were fixed on to the fracture fragments subperiosteally using hemicerclage wiring. External immobilization was achieved by means of four bamboo splints and plaster of paris cast.

Group B - Consisting of six animals numbered serially from B/I to B/VI

A complete transverse midshaft fracture was created on the right metacarpus by open method. Four bamboo splints and plaster of paris cast were applied to achieve immobilization.

A sham operation was conducted at the same site on the left metacarpal region of all the animals of both the groups

Procedure

Pre-operative Preparation

The animals were prepared by withholding feed for 24 hours and water for 12 hours prior to surgery. Entire right and left limbs were thoroughly scrubbed with cetrimide lotion¹. The entire metacarpal region was shaved, washed first with soap and water and then with 70 per cent alcohol. After drying the area was painted with Tr Iodine. The animals were controlled in right lateral recumbency. In group A the area over the left last rib was shaved and prepared as in the case of the metacarpal region. Limbs and chest were suitably draped.

Anaesthesia

Triflupromazine hydrochloride² at the rate of 0.25 mg/kg body weight was administered IM and was followed by

-
- | | | | |
|------------|--------------------------|-----------------------|--------|
| 1 SAVLON | cetrimide | Indian Explosives Ltd | Madras |
| 2 SIQUIL | SG Pharmaceuticals | Baroda | |
| 3 CALIPOSE | Ranbaxy Laboratories Ltd | Dewas | M P |

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70634

Diazepam³ at the rate of 0.20 mg/kg body weight IV for effecting sedation. Diazepam was repeated if it was found necessary during the surgery.

Local anaesthesia was achieved by linear infiltration of two per cent solution of lignocaine hydrochloride⁴ seven to ten millilitres at the sites of operation (Fig 1) viz

- 1 Antero medial aspect of the left and right metacarpal region in Group A and B and
- 2 the skin over the last rib on the left side in Group A

Technique

Group A

A cutaneous incision 10 cm long was made over the last rib on the left side. The subcutaneous fascia and the periosteum of the rib were incised and the periosteum was separated. Using rib shears a piece of rib eight centimeters long was cut and removed. The incision on the periosteum was closed by continuous lock stitch using 1/0 silk. Skin and subcutaneous tissue were sutured by horizontal mattress sutures using monofilament nylon. Tr benzoin seal was applied over the suture line.

4 XYLOCAINE 2% Astra IDL Ltd Bangalore

Fig 1

Animal showing the site of operation Tr Iodine
painted line indicates the line of incision



The harvested rib was cut into two pieces of four centimeters in length. Corners of each graft were rounded off. Using a bone drill, one hole each was drilled on both ends of the grafts 1.5 cm away from the midpoint, on the midline.

The prepared grafts were kept covered with sterilised gauze soaked in sterile normal saline.

A cutaneous incision 10 cm long was made on the antero-medial aspect of the right metacarpal region. The subcutaneous fascia and periosteum were incised. Periosteum was separated all around the bone. Using a sterilized hacksaw blade, the bone was cut transversely in the midshaft region upto 3/4th of its thickness and then broken manually to create a complete transverse fracture.

The fracture was reduced. Two rib grafts were kept in position, one over the anterior aspect and the other over the posterior aspect of the metacarpus subperiosteally. Holes were drilled on each of the fractured fragment at points corresponding to the holes drilled on the rib grafts. The rib grafts were secured in position by hemicerclage wiring using stainless steel wire size No. 28.

The periosteum was apposed by continuous lock stitch using 1/0 silk and the skin by horizontal mattress sutures using monofilament nylon. Tr. benzoin seal was applied over

the suture line and the region was bandaged Four cotton padded bamboo splints of sufficient length to cover the knee above and fetlock below were placed over the metacarpal region and secured in position with tapes A plaster of paris bandage was applied over the splints, covering the knee joint above and extending upto the hoof below

A sham operation was done on the left limb at the same site securing the animal in the left lateral recumbency

The animals were assisted to stand up after the plaster cast was set

Group B

A complete transverse midshaft fracture was created as in Group A After reducing the fracture, the periosteum and skin incision were sutured as in Group A Suture line was sealed with Tr benzoin and the metacarpal region was bandaged Four cotton padded bamboo splints of sufficient length to cover the knee above and fetlock below were placed over the metacarpal region and secured in position with tapes A plaster of paris bandage was applied over the splints covering the knee joint above and extending upto the hoof below A plaster of paris cast was applied as in Group A

A sham operation was done on the left limb at the same site with the animals on left lateral recumbency as in Group A

The animals were assisted to stand up after the plaster cast was set

Sham Operation

A skin incision of 10 cm length was made on the antero-medial aspect of the left metacarpal region and the subcutaneous fascia was dissected to expose the periosteum. The skin incision was apposed by horizontal mattress sutures using monofilament nylon. Tr benzoin seal was applied over the suture line and the metacarpal region was bandaged.

Post operative Care

The animals were kept under observation for varying periods upto six weeks. Streptopenicillin⁵ (1.25 G) was administered IM for 10 consecutive days. Analgin⁶ (2.5 G) was administered IM for five consecutive days to all animals. Suture lines at the sham operation site and rib harvest site were cleaned with spirit and dressed with nitrofurazone ointment⁷ daily.

The plaster of paris cast was maintained throughout the period of observation. Skin sutures at the sham operation site and rib harvest site were removed on healing of the wound. The sutures at the fracture site were retained till the end of the period of observation.

-
- 5 DICRYSIICIN-S LARGE DOSE - Sarabhai Chemicals, Baroda
 - 6 NOVALGIN - Hoechst India Ltd Bombay
 - 7 FURACIN VE1 Eskayef Bangalore

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Two animals in Group A were sacrificed at two weeks and four weeks respectively and two animals in Group B were also sacrificed at two weeks and four weeks respectively. The remaining animals in both the groups were sacrificed at sixth week.

The following observations were recorded

- 1 Clinical symptoms efficacy of immobilization and functional status of the limbs
- 2 Radiographic evaluation of the progress of healing at weekly intervals (Fig 2)
- 3 Macroscopic study of the harvested metacarpal bone and histological study of the callus

Histological Technique

Pieces of bone along with the callus were cut in sizes of 5mm thickness from the fracture site, fixed, decalcified, dehydrated, cleared and embedded in paraffin. Sections 5-10 μ m thickness were prepared and stained using haematoxylin and eosin stains (Drury et al 1967).

Fig 2 - Radiograph of the right metacarpus just prior to osteotomy

Fig 3 - Radiograph of the right metacarpus immediately after rib grafting and application of plaster of Paris cast. Fragments in apposition and graft in position



Results

RESULTS

GROUP - A

ANIMAL NO A/I

CLINICAL SYMPTOMS

First week

Animal was able to get up and lie down with difficulty and was reluctant to walk. It evinced signs of pain while walking and was limping. It favoured the fractured limb with the toe touching the ground. It exhibited pawing with the fractured limb. There was no oedema proximal or distal to the plaster cast. On the fifth day since the cast was found stained at the fracture site a window was cut. The sutures were intact. At the fracture site there was oedema with slight oozing of serous discharge. The wound was cleaned with spirit, dressed with nitrofurazone ointment and bandaged.

Second week

Animal was getting up and lying down without assistance. There was no pain while walking. It was limping and stumbling while walking fast. It favoured the fractured limb with the toe touching the ground and exhibited pawing. Skin sutures from the rib harvest site and the sham

operation site were removed on the 10th day since the wounds had healed There was infection and formation of pus on the suture line at the site of fracture and the dressing of the wound was continued

Third week

Animal could get up and lie down without assistance Limping with occasional stumbling was noticed Pawing action was observed Nodding of the head also was seen The wound was cleaned dressed and bandaged

Fourth week

Animal could get up lie down and walk without assistance Limping stumbling and nodding were noticed Pawing action with the operated limb and favouring it were also observed There was an increase in the slope of the pastern of the left fore limb There was no pus in the wound and it was healing Wound was cleaned dressed and bandaged

Fifth week

Animal was bearing weight on the fractured limb Limping favouring of the limb and nodding were slight and stumbling was not observed Pawing action was still present The dressing of the wound was continued on alternate days

Sixth week

Animal could bear weight on the fractured limb
Limping favouring of the limb and nodding were still
present Pawing action also was observed There was an
increase in the slope of the pastern of the left fore limb

The animal was sacrificed on the 42nd day On removing
the plaster cast the skin wound at the fracture site was
found to have healed up The right metacarpus was dissected
out Thick callus was observed around the fracture site and
there was no mobility of the fragments

PLASTER CAST

The plaster cast remained intact throughout the period
of observation though few cracks developed above the knee
region and at the distal third of the cast by the fifth
week

RADIOGRAPHIC OBSERVATIONS

First day Fragments were in apposition with the grafts in
position Fracture line was distinct (Fig 3)

First week Fragments were in apposition with slight
displacement of the distal fragment The grafts were in
position and the fracture line was distinct (Fig 4)

Fig 4 - Radiograph of the right metacarpus with rib grafts after one week. Slight displacement of the distal fragment

Fig 5 Radiograph of the right metacarpus three weeks after rib grafting. Slight displacement of the distal fragment



Second week Fragments were in apposition with slight displacement of the distal fragment The grafts were in position and the fracture line was distinct

Third week fragments were in apposition with slight displacement of the distal fragment The grafts were in position and the fracture line was distinct (Fig 5)

Fourth week Fragments were in apposition with slight displacement of the distal fragment The grafts were in position and the fracture line was distinct

Fifth week Fragments were in apposition with slight displacement of the distal fragment Callus was noticed on both proximal and distal fragments adjacent to the fracture site Grafts were visible and in position Fracture line was partially obliterated

Sixth week Fragments were in apposition with slight displacement of the distal fragment Well developed osseous callus was noticed on both the fragments and it was continuous between the fragments The grafts could not be differentiated Fracture line was partially obliterated

Radiograph of the harvested bone Bone fragments were in apposition with slight displacement of the distal fragment Well developed osseous callus involving both the fragments

was present Grafts could not be differentiated within the callus Partial obliteration of the fracture line was noticed

HISTOLOGICAL OBSERVATIONS

There was proliferation of the periosteum which was covering the callus The callus showed replacement of the graft tissue with proliferation of blood vessels connective tissue and new osseous trabeculae The cortical bone was normal Extensive new bone formation was noticed adjacent to the graft and the cortical bone There was minimal proliferative reaction within the marrow cavity

ANIMAL NO A/II

CLINICAL SYMPTOMS

First week

Animal was able to get up lie down and walk without assistance It could bear weight on the fractured limb though with favouring of the limb Slight limping was observed No oedema was present proximal or distal to the plaster cast

Second week

Animal favoured the fractured limb and nodding was present Slight limping was noticed while walking Skin sutures at the rib harvest site and sham operation site were removed on the 10th day since the wounds had healed up

Third week

Though the animal could get up lie down walk without assistance and bear weight on the operated limb there was favouring of the limb Slight limping and nodding were still present there was an increase in the slope of the pastern of the left fore limb

Fourth week

Animal could bear weight on the operated limb even though there was favouring of the operated limb Slight limping and nodding were noticed only while walking fast

Fifth week

Favouring the limb was observed Nodding was present while running Slope of the pastern of the left fore limb had further increased

Sixth week

The animal was sacrificed on the 42nd day On removing the plaster cast the skin wound at the fracture site was

found to have healed up The right metacarpus was dissected out There was a well developed callus at the fracture site and there was no mobility of the fragments

PLASTER CAST

The plaster cast remained intact throughout the period of observation

RADIOGRAPHIC OBSERVATIONS

First day Fragments were in apposition with the grafts in position Fracture line was distinct

First week Fragments were in apposition with slight displacement of the distal fragment The grafts were in position and the fracture line was distinct

Second week Fragments were in apposition with slight displacement of the distal fragment The grafts were in position and the fracture line was distinct

Third week Fragments were in apposition with slight displacement of the distal fragment Callus was noticed on both proximal and the distal fragments adjacent to the fracture site Grafts were visible and in position The fracture line was distinct

fourth week Fragments were in apposition with slight displacement of the distal fragment Callus formation was more marked The grafts were in position Fracture line was partially obliterated (Fig 6)

Fifth week Fragments were in apposition with slight displacement of the distal fragment Well developed callus involving both the fragments was observed Grafts could not be differentiated Partial obliteration of the fracture line was noticed

Sixth week Fragments were in apposition with slight displacement of the distal fragment Well developed, osseous callus involving both the fragments was noticed Grafts could not be differentiated Partial obliteration of the fracture line was observed

Radiograph of the harvested bone Fragments were in apposition with slight displacement of the distal fragment Well developed osseous callus involving both the fragments was present Grafts could not be differentiated Partial obliteration of the fracture line was noticed

HISTOLOGICAL OBSERVATIONS

There was proliferation of the periosteum covering the callus There were extensive areas of graft resorption with

Fig 6 Radiograph of the right metacarpus four weeks after rib grafting. New bone formation present with partial obliteration of the fracture line.

Fig 7 Radiograph of the right metacarpus five weeks after rib grafting. Slight displacement and deviation of the distal fragment. Osseous callus present with partial obliteration of the fracture line.





proliferation of blood vessels connective tissue and new bone trabeculae The cortical bone showed focal areas of necrosis New trabecular bone formation was noticed adjacent to cortical bone

ANIMAL NO A/III

CLINICAL SYMPTOMS

First week

Animal was able to get up and lie down without help There was favouring of the limb Nodding and limping were observed There was no oedema proximal or distal to the plaster cast

Second week

Animal was getting up and lying down unassisted There was favouring of the limb Nodding and limping were noticed The wound at the rib harvest site and the sham operation site had healed up by 10th day and the skin sutures were removed

Third week

Animal was getting up lying down and walking without assistance It was not able to bear weight on the fractured limb Slight nodding and limping were also exhibited

Fourth week

Animal was able to get up, lie down and walk without assistance. It was not able to bear weight on the fractured limb. Slight nodding and limping were observed.

The animal was sacrificed on 28th day. On removing the plaster cast, the skin wound at the fracture site was found to have healed up. The right metacarpus was dissected out. There was a well developed callus at the fracture site and there was no mobility of the fragments.

PLASTER CAST

The plaster cast remained intact throughout the period of observation.

RADIOGRAPHIC OBSERVATIONS

First day: Fragments were in apposition with the grafts in position. Fracture line was distinct.

First week: Fragments were in apposition with slight displacement of the distal fragment. The grafts were in position and the fracture line was distinct.

Second week: Fragments were in apposition with slight displacement of the distal fragment. The grafts were in position and the fracture line was distinct.

Third week Fragments were in apposition with slight displacement of the fragment Grafts were in position and the fracture line was distinct

Fourth week Fragments were in apposition with slight displacement of the distal fragment Osseous callus was noticed on both proximal and distal fragments close to the fracture site Grafts were in position and the fracture line was distinct

Radiograph of the harvested bone Fragments were in apposition with slight displacement of the distal fragment Osseous callus was noticed close to the fracture site Grafts were in position and the fracture line was distinct

HISTOLOGICAL OBSERVATIONS

There was proliferation of the periosteum There were extensive areas of graft resorption with proliferation of blood vessels connective tissue and new bone trabeculae The cortical bone showed focal areas of necrosis New bone formation was noticed adjacent to the cortical bone

ANIMAL NO A/IV

CLINICAL SYMPTOMS

First week

Animal was able to get up and lie down without assistance though not bearing weight on the fractured limb. There was favouring of the fractured limb and the toe was touching the ground. Nodding and limping were observed. No oedema was noticed proximal or distal to the plaster cast.

Second week

Animal was able to get up and lie down without assistance. It was unable to bear weight on the fractured limb. There was favouring of the operated limb. Nodding and limping were present. The wounds at the rib harvest site and the sham operation site had healed and the skin sutures were removed on the 10th day.

Third week

Animal could get up and lie down without assistance and walk briskly. But it was not able to bear weight on the fractured limb. Favouring of the limb, nodding and limping were less prominent.

Fourth week

Animal could get up lie down and walk without assistance Animal was unable to bear weight on the operated limb Favouring of the limb and nodding were present There was slight limping while walking fast

Fifth week

Animal started bearing weight on the operated limb Favouring of the limb limping and nodding were exhibited

Sixth week

Animal was able to bear weight on the fractured limb Favouring of the limb was very slight while standing Nodding and limping were very mild while walking fast

The animal was sacrificed on the 42nd day On removing the plaster cast the skin wound at the fracture site was found to have healed up The right metacarpus was dissected out There was a well developed callus at the fracture site and there was no mobility of the fragments

PLASTER CAST

The plaster of paris cast remained intact throughout the period of observation

RADIOGRAPHIC OBSERVATION

First day Fragments were in apposition with slight displacement of the distal fragment The grafts were in position and the fracture line was distinct

First week There was slight displacement and deviation of the fragments The grafts were in position and the fracture line was distinct

Second week There was slight displacement and deviation of the fragments Grafts were in position and the fracture line was distinct

Third week There was slight displacement and deviation of the fragments Grafts were in position and the fracture line was distinct

Fourth week There was slight displacement and deviation of the fragments Grafts were in position and the fracture line was distinct

Fifth week There was slight displacement and deviation of the fragments Formation of callus was noticed on both the fragments near the fracture site The grafts were in position Fracture line was partially obliterated (Fig 7)

Sixth week There was slight displacement and deviation of the fragments Formation of well developed osseous callus

was noticed The grafts were visible Fracture line was partially obliterated (Fig 8)

Radiograph of the harvested bone There was slight displacement and deviation of the fragments Well developed osseous callus was noticed at the fracture site continuous between the fragments The grafts were visible Fracture line was partially obliterated

HISTOLOGICAL OBSERVATIONS

There was proliferation of the periosteum with the periosteal callus continuous with the cortical bone The graft was seen replaced by the granulation tissue and new trabecular bone Focal areas of necrosis was observed in the cortical bone New trabecular bone formation was noticed from the periphery of the cortical bone into the external callus

ANIMAL NO A/V

CLINICAL SYMPTOMS

First week

Animal was not able to get up and remained on sternal recumbency It could stand up only on the third day that

Fig 8 Radiograph of the right metacarpus six weeks
after rib grafting. Well developed osseous
callus involving both the fragments. Fracture
line partially obliterated.

Fig 9 - Radiograph of the harvested right metacarpal
bones (Group A) after rib grafting. Specimen
harvested after two weeks(2) four weeks(4) and
six weeks(6)



too with assistance but could lie down by itself It started walking slowly by the fourth day It favoured the operated limb while standing and could not bear weight on the fractured limb Nodding and limping were observed No oedema was noticed proximal or distal to the plaster cast

Second week

Animal had to be assisted to get up and to walk It could not bear weight on the operated limb Favouring of the limb was observed Nodding and limping were marked The wounds at the rib harvest site and sham operation site had healed and the skin sutures were removed on the 10th day

The animal was sacrificed on 14th day On removing the plaster cast, the skin wound at the fracture site was found to have healed up The right metacarpus was dissected out Callus formation was noticed at the fracture site There was mobility of the fragments at the fracture site

PLASTER CAST

Plaster cast was moist but was intact throughout the period of observation

RADIOGRAPHIC OBSERVATIONS

First day Fragments were in apposition The grafts were in position Fracture line was distinct

First week Marked displacement of the distal fragment resulting in incomplete apposition was observed Grafts also were displaced Fracture line was distinct

Second week Marked displacement of the distal fragment resulting in incomplete apposition was observed Grafts also were displaced Fracture line was distinct

Radiograph of harvested bone Displacement of the distal fragment resulting in incomplete apposition was noticed Grafts also were displaced Fracture line was distinct (Fig 9)

HISTOLOGICAL OBSERVATIONS

There was proliferation of the periosteum with vascularisation and cellular infiltration There were zones of graft resorption Fibroblasts and infiltrating cells were seen especially below the periosteum New trabecular bone was seen at the periphery of the graft

ANIMAL NO A/VI

CLINICAL SYMPTOMS

First week

Animal was getting up and lying down without assistance and was walking. It was not able to bear weight on the operated limb and was limping. Favouring of the limb and nodding were noticed. No oedema was seen proximal or distal to the plaster cast.

Second week

Animal was able to get up and lie down without assistance. It was unable to bear weight on the operated limb. It favoured the operated limb at rest. Limping and nodding were observed. The wounds at the rib harvest site and sham operation site had healed and the skin sutures were removed on the 10th day.

Third week

Animal was able to get up and lie down unassisted. It was able to support partially on the fractured limb. Favouring of the limb, limping and nodding were less prominent.

Fourth week

Animal could get up and lie down without assistance
It was able to bear weight on the fractured limb It
exhibited pawing action with the fractured limb

Fifth week

Animal was able to stand up and walk normally but the
pawing action persisted There was no lameness

Sixth week

Animal was able to stand up and walk normally But
pawing action was still observed

The animal was sacrificed on the 42nd day On removing
the plaster cast the skin wound at the fracture site was
found to have healed up The right metacarpus was dissected
out There was a well developed callus and there was no
mobility of the fragments There was slight angulation of
the bone

PLASTER CAST

Plaster cast developed few cracks at its distal region
by the fourth week and had been reinforced

RADIOGRAPHIC OBSERVATIONS

First day Fragments were in apposition with slight displacement of the distal fragment The grafts were in position and the fracture line was distinct

First week There was slight displacement and marked deviation of the distal fragment The grafts were in position and the fracture line was distinct

Second week There was slight displacement and marked deviation of the distal fragment The grafts were in position and the fracture line was distinct

Third week There was slight displacement and marked deviation of the distal fragment The grafts were in position and the fracture line was distinct

Fourth week There was slight displacement and marked deviation of the distal fragment Osseous callus was noticed on both proximal and distal fragments Grafts could not be differentiated within the callus The fracture line was partially obliterated

Fifth week There was slight displacement and marked deviation of the distal fragment resulting in slight angulation of the bone The osseous callus was more extensive on both the fragments near the fracture site

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Grafts could not be differentiated within the callus
Fracture line was partially obliterated

Sixth week There was slight displacement and marked deviation of the distal fragment resulting in slight angulation of the bone Well developed osseous callus was observed involving both the fragments Grafts could not be differentiated within the callus Fracture line was partially obliterated

Radiograph of the harvested bone There was slight displacement and marked deviation of the distal fragment resulting in slight angulation of the bone Well developed osseous callus was observed involving both the fragments and the grafts could not be differentiated within the callus Fracture line was partially obliterated

HISTOLOGICAL OBSERVATIONS

Proliferation of the periosteum was noticed There were large areas of graft resorption with proliferation of blood vessels and connective tissue along with hyaline cartilage formation There were zones of cartilage ossification in the callus

From the foregoing findings, it could be observed that,

Sedation with triflupromazine hydrochloride at the rate of 0.25 mg/kg body weight IM and diazepam at the rate of 0.20 mg/kg body weight IV, followed by local infiltration analgesia using two per cent solution of lignocaine hydrochloride was satisfactory for the surgical manipulations

Resection of periosteum over the metacarpus could be done after incising it longitudinally and separating it from the underlying cortical bone. After fixing the rib graft, continuous lock stitch using 1/0 silk was placed on the periosteal incision. On cropping the metacarpus at varying periods of the experiment it was seen that the periosteum had united firmly and the gap was filled in with callus

Grafts were retained in position and could not be differentiated from the callus. Rejection of the graft was not observed in any of the animals

A Clinical findings

1 All the animals except A/V could get up and lie down without difficulty during the first week. Animal A/V showed difficulty in getting up for two weeks

- observed
- 2 Pain while walking was [^] only in A/I during the first week
- 3 The animals A/II started bearing weight on the operated limb from the first week A/VI from the fourth week and A/I and A/IV from the fifth week Animals A/III and A/V during the period of observation of four weeks and two weeks respectively did not bear weight on the limb
- 4 Favouring the fractured limb was observed in animal A/II till the fifth week and A/VI till the fourth week and throughout the period of observation in all the other animals
- ↓
- 5 Nodding of the head and limping could be noticed throughout the period of observation in animals, A/III, A/IV and A/V till the fifth week in A/VI, from the third week onwards in A/I and from the second to the fifth week in A/II
- 6 Stumbling was observed in animal A/IV for the first week and in A/I for the first four weeks
- 7 Pawing with the fractured limb was observed throughout the period of observation in A/I and during the fifth and sixth weeks in A/VI It was not observed in other animals

8 Increase in the slope of the pastern of the left forelimb was noticed from the fourth week onwards in animal A/I and from the third week onwards in animal A/II

B Plaster cast

In all the animals, plaster cast remained intact throughout the period of observation. A few cracks were noticed at the distal and proximal ends but did not affect the stability of the cast.

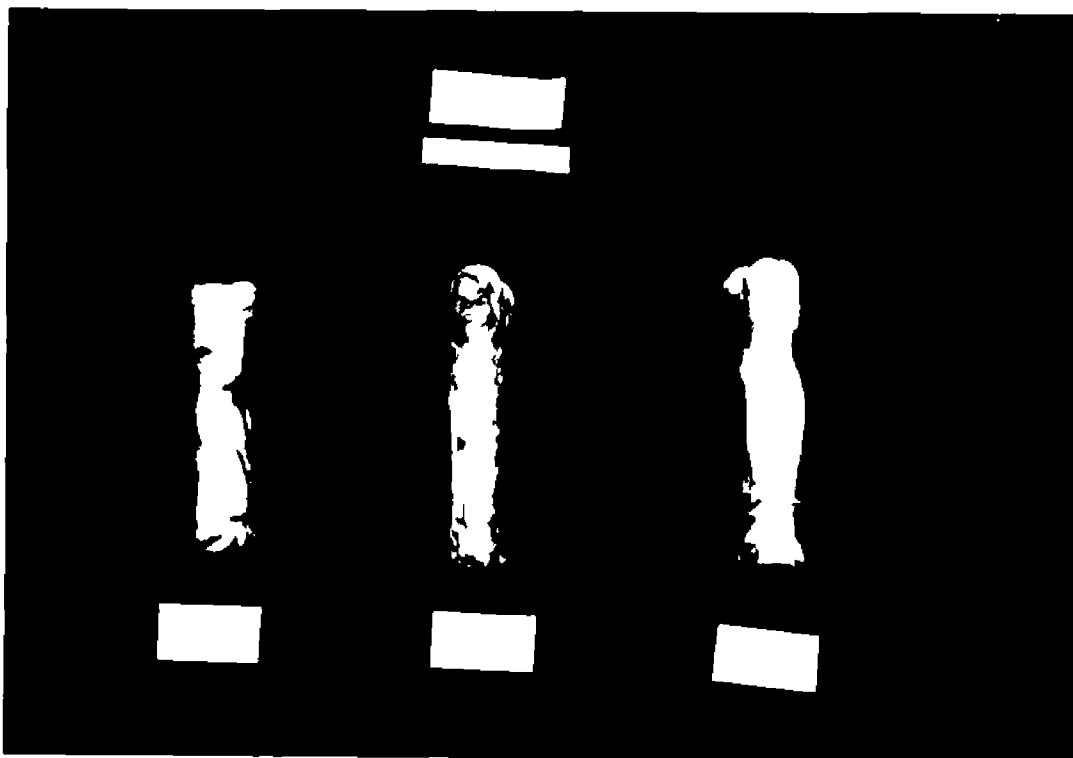
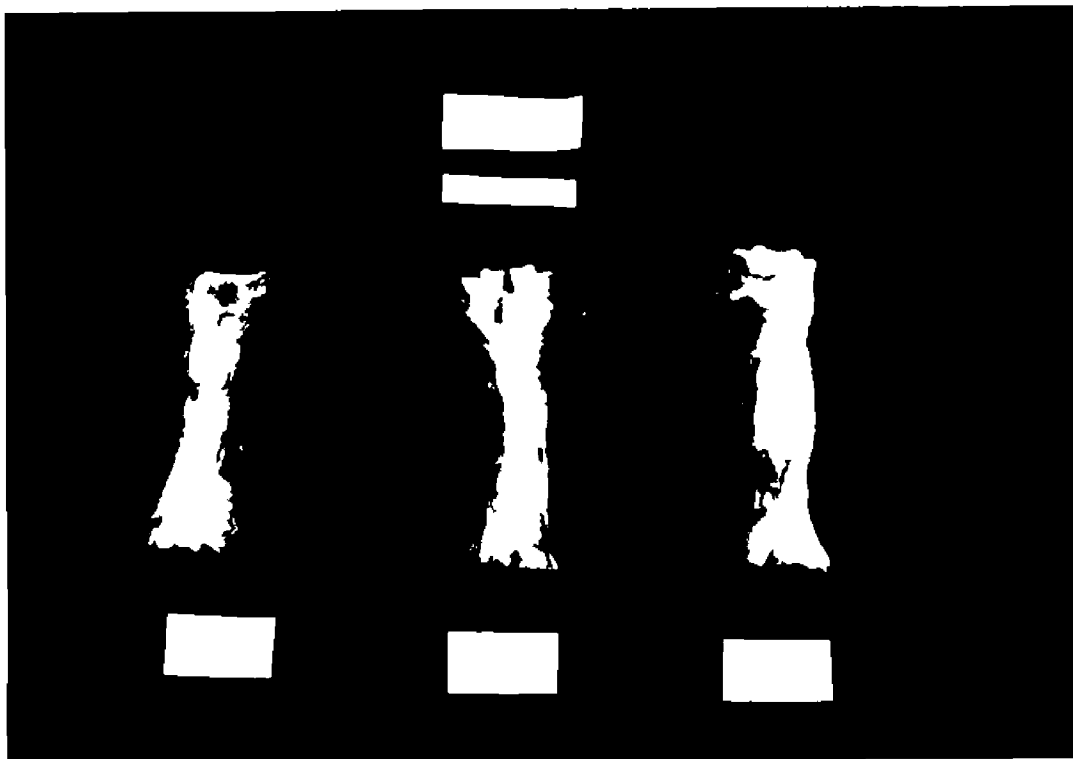
C Radiographic findings

1 In all the animals slight displacement of the fragments was noticed from the first week onwards. However the apposition of the fragments was satisfactory throughout the period of observation. The displacement was marked in A/V resulting in incomplete apposition. Marked deviation of the fragments was noticed in A/VI resulting in angulation at the fracture site.

2 Grafts were in position in all the animals throughout the period of observation. The grafts could not be differentiated in radiographs by the sixth week in A/I, fifth week in A/II and by the fourth week in A/VI.

Fig 10 Bones cropped in Group A - Dorsal view Six weeks
after rib grafting four weeks after rib grafting
and two weeks after rib grafting

Fig 11 Bone of of Lateral Six
of rib graft four weeks after rib
of two weeks after rib
grafting



3 Radiographically visible callus was noticed by the third week in A/II by the fourth week in A/III and A/VI and by the fifth week in A/I and A/IV but was not observed in A/V where the period of observation was two weeks. Partial obliteration of the fracture line was observed by the fourth week in A/II and A/VI and by the fifth week in A/I and A/IV but was not observed in A/V and A/III where the period of observation was two weeks and four weeks respectively.

D Cross findings of the callus

The harvested right metacarpus showed well developed thick callus bridging both the fragments. The fragments were united without mobility in all the animals except A/V. Slight mobility of the fragments was observed in Animal A/V where the period of observation was two weeks (Fig 10 & 11).

E Histological findings

Second week

There was proliferation of the periosteum with vascularisation and cellular infiltration. There were zones of graft resorption. Fibroblasts and infiltrating cells were seen especially below the periosteum. New trabecular bone was seen at the periphery of the graft (Fig 12 & 13).

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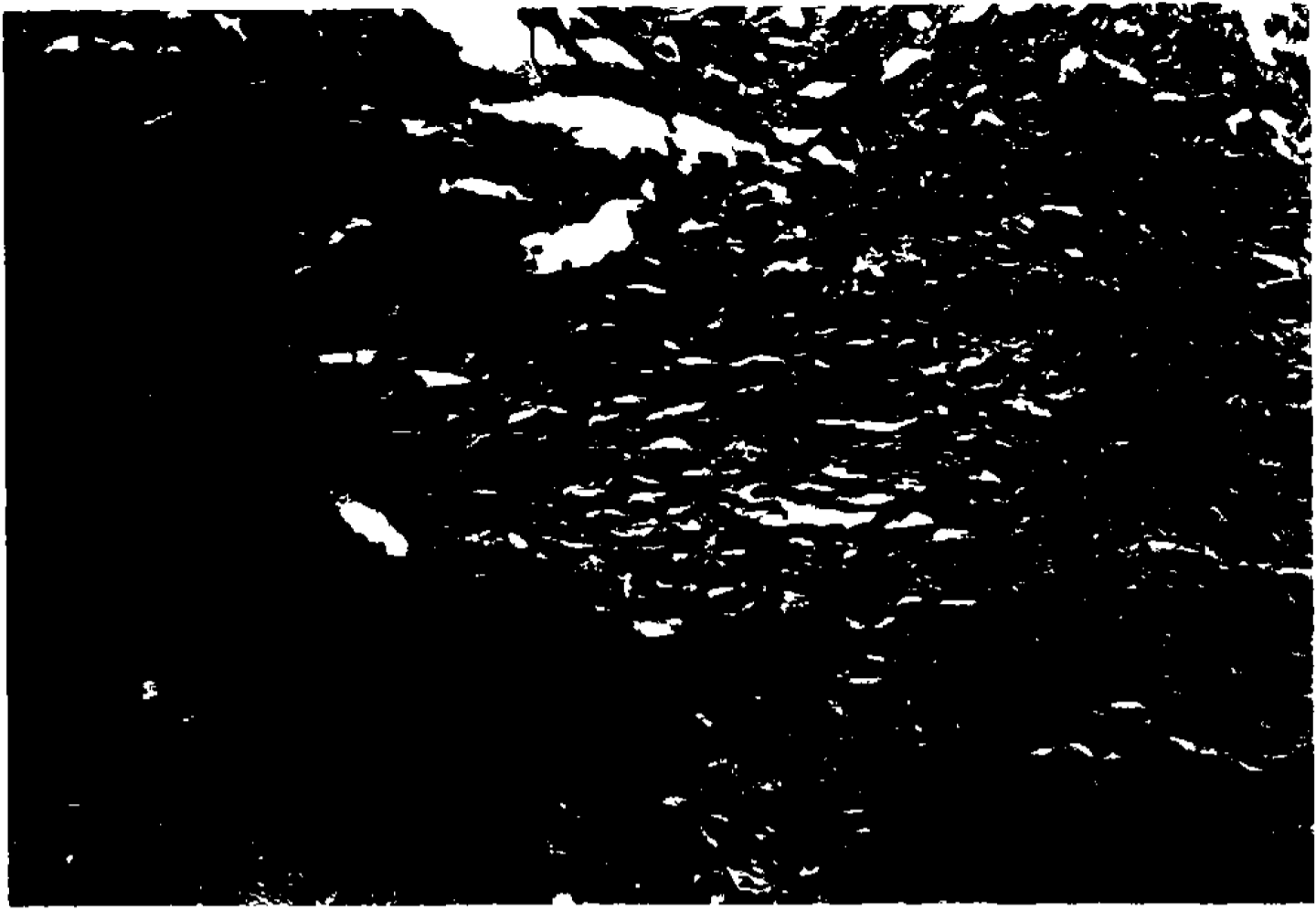


Fig 14 Photomicrograph of the callus at four weeks in Group A Showing proliferation of connective tissue and trabecular new bone formation in the external callus

Fig 15 - Photomicrograph of the callus at four weeks in Group A Showing early connective tissue proliferation and new trabecular formation under the periosteum



Fig 16 Photomicrograph of the callus at four weeks in Group A Showing new bone growth lined by Osteoblasts extending from the surface of the cortex into the external callus

Fig 17 Photomicrograph of the callus at six weeks in Group A Showing new trabecular bone formation at the periphery of the graft

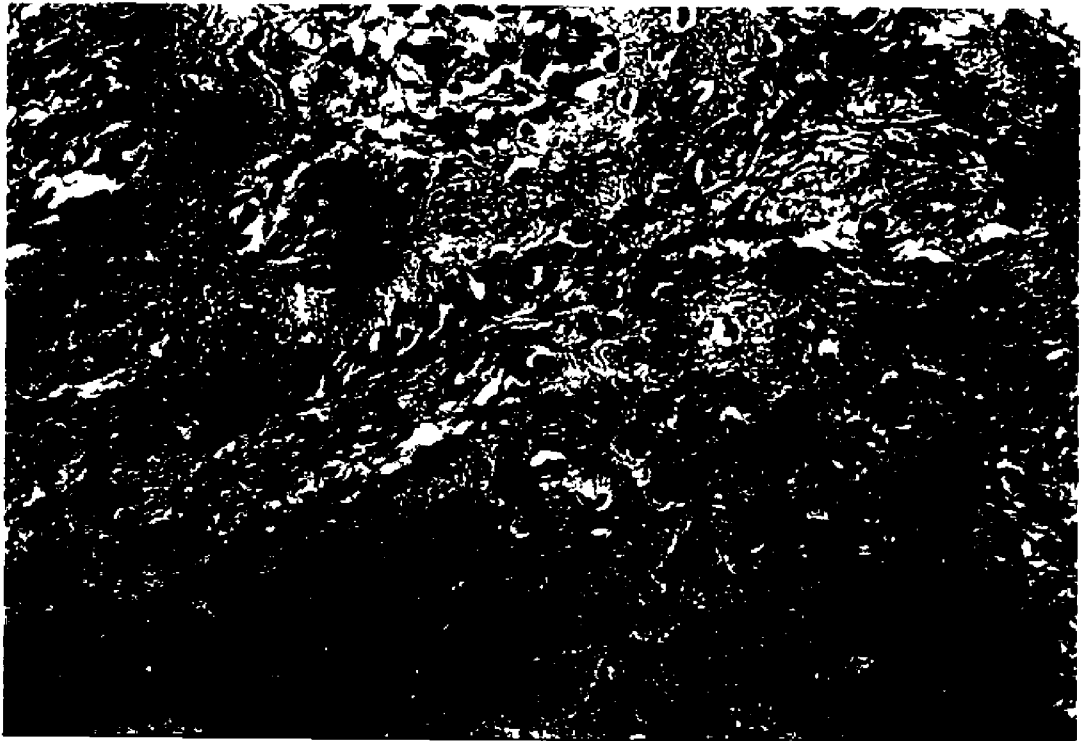
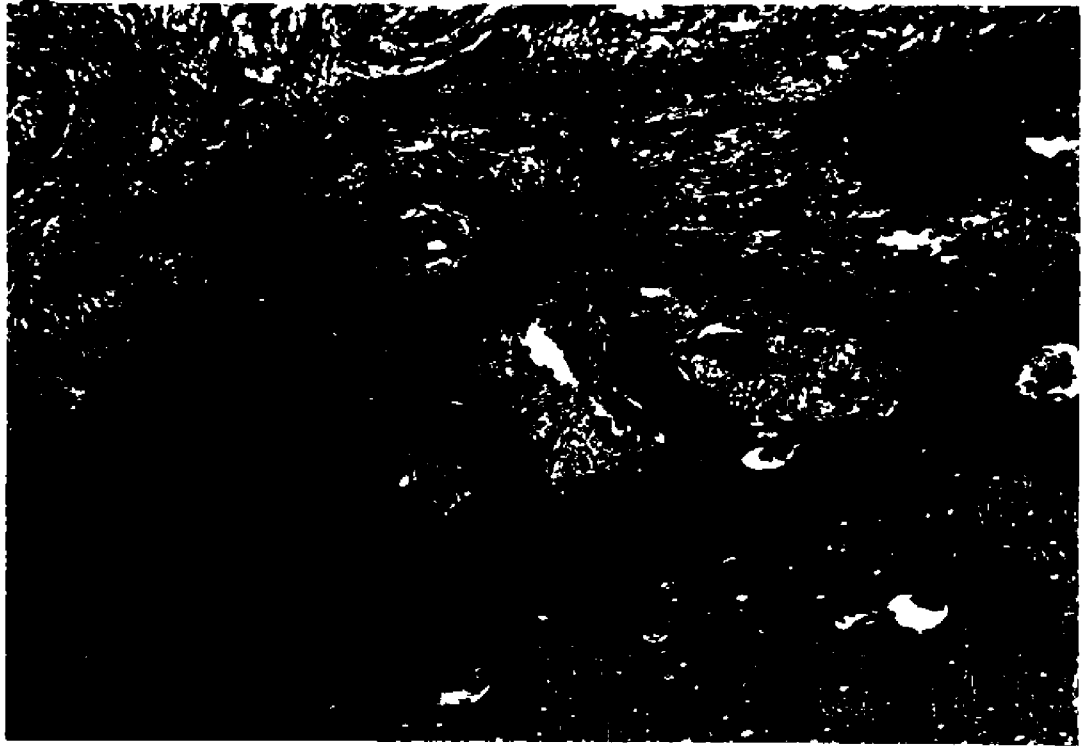


Fig 18 Photomicrograph of the callus at six weeks in
Group A Showing host cortex graft interface
and the resorption areas of graft and cortex



Fourth week

There was proliferation of the periosteum. There were extensive areas of graft resorption and replacement with blood vessels, connective tissue and new bone trabeculae (Fig 14 & 15). The cortical bone showed focal areas of necrosis. New bone formation was noticed adjacent to the cortical bone (Fig 16).

Sixth week

There was proliferation of the periosteum. There were extensive areas of graft resorption and replacement with blood vessels, connective tissue and new bone trabeculae (Fig 17 & 18). Zones of hyaline cartilage were noticed in the specimen from animal A/VI. Focal necrosis of the cortical bone was observed in two animals viz, A/II and A/IV.

F Sham operation

The wound healing was uneventful and the sutures were removed on the 10th day post operative.

ANIMAL NO B/I

CLINICAL SYMPTOMS

First week

Animal was able to get up and lie down without assistance. But it could not bear weight on the operated

limb There was favouring of the fractured limb and nodding of the head It exhibited pawing action with the fractured limb

Second week

Animal was able to get up and lie down without assistance It could not bear weight on the operated limb There was favouring of the limb Nodding and limping were observed It exhibited pawing action with the fractured limb Wound at the sham operation site had healed and the sutures were removed on the 10th day

Third week

Animal could move about more freely It could bear weight on the fractured limb partially There was favouring of the fractured limb and limping Nodding was less marked It exhibited pawing action with the operated limb

Fourth week

Animal could get up and lie down normally It could bear weight on the fractured limb partially It favoured the limb while standing and limping was noticed during progression It exhibited pawing action with the fractured limb

Fig 19 - Radiograph of the fractured right metacarpus immediately after reduction and application of plaster cast. Slight posterior deviation of the distal fragment

Fig 20 - Radiograph of the right metacarpus One week after application of plaster cast. Slight posterior deviation of the distal fragment



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Animal was sacrificed on the 28th day On removing the plaster cast, the skin wound at the fracture site was found to have healed The right metacarpus was dissected out There was a well developed callus uniting the fragments and there was no mobility of the fragments

PLASTER CAST

Plaster cast remained intact throughout the period of observation

RADIOGRAPHIC OBSERVATION

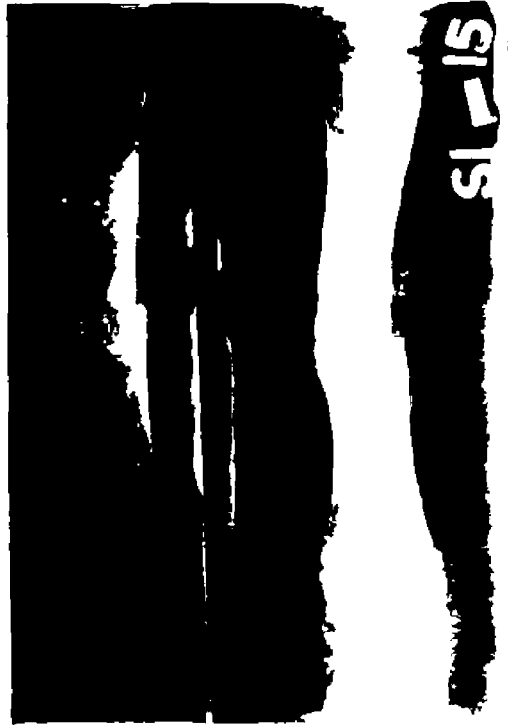
First day Fragments were in apposition with slight posterior deviation of the distal fragment Fracture line was distinct (Fig 19)

First week Fragments were in apposition with marked posterior deviation of the distal fragment Fracture line was distinct (Fig 20)

Second week Fragments were in incomplete apposition Slight displacement and marked posterior deviation of the distal fragment were noticed Callus formation was observed on the distal fragment close to the fracture site Fracture line was distinct (Fig 21)

Fig 21 - Radiograph of the right metacarpus two weeks after application of plaster cast Osseous callus on the distal fragment near the fracture site

Fig 22 Radiograph of the right metacarpus three weeks after application of plaster cast Marked new bone formation and partial obliteration of fracture line



Third week Fragments were in incomplete apposition Slight displacement and marked posterior deviation of the distal fragment were noticed Callus formation was noticed on both the fragments close to the fracture site Fracture line was distinct

Fourth week Fragments were in incomplete apposition Marked displacement and posterior deviation of the fragment were observed There was well developed callus on both the fragments Partial obliteration of the fracture line was noticed

Radiograph of the harvested bone Fragments were in incomplete apposition Marked displacement and posterior deviation of the distal fragment were noticed There was well developed callus on both the fragments Partial obliteration of the fracture line was observed

HISTOLOGICAL OBSERVATIONS

There was proliferation of periosteum The callus showed zones of newly formed connective tissue Hypertrophied cartilage cells with ossification at the periphery of the cartilage was observed New trabecular bone was seen extending from the surface of the cortical bone into the callus

ANIMAL NO B/II

CLINICAL SYMPTOMS

First week

Animal had to be assisted to get up walk and also to lie down There was favouring of the fractured limb and it walked with swaying gait

By the end of the week animal could not stand up even with assistance

Second week

Animal was weak and was not able to get up It remained on sternal recumbency throughout the week However it was taking feed and water normally Wound at the sham operation site had healed up and the sutures were removed on the 10th day

Animal was sacrificed on 14th day On removing the plaster cast the skin wound at the fracture site was found to have healed up The right metacarpus was dissected out There was callus formation around the fracture site Mobility of the fragments was observed

PLASTER CAST

Plaster cast remained intact throughout the period of observation

RADIOGRAPHIC OBSERVATIONS

First day There was marked posterior displacement of the distal fragment with incomplete apposition at the fracture site Fracture line was distinct

First week There was marked posterior displacement of the distal fragment with incomplete apposition at the fracture site Fracture line was distinct

Second week There was marked posterior displacement of the distal fragment with incomplete apposition at the fracture site Fracture line was distinct

Radiograph of the harvested bone There was marked posterior displacement of the distal fragment with incomplete apposition at the fracture site There was callus formation involving both the fragments near the fracture site The fracture line was distinct

HISTOLOGICAL OBSERVATIONS

Extensive external callus formation was observed. There was organisation of blood clot between the periosteum and cortical bone. Proliferation of the connective tissue with osseous trabeculae formation was noticed in the callus.

ANIMAL NO B/III

CLINICAL SYMPTOMS

First week

Animal was getting up and lying down without assistance. It could not bear weight on the operated limb. It could walk very slowly. There was favouring of the limb. Nodding and limping were noticed. There was no oedema proximal or distal to the plaster cast.

Second week

Animal could get up and lie down without assistance. It could bear weight on the operated limb partially and there was favouring of the limb. Nodding and limping were observed. Wound at the sham operation site had healed up and the sutures were removed on the 10th day.

Third week

Animal could get up and lie down and was able to bear weight on the operated limb Favouring of the limb was not observed Nodding and limping were present while walking fast

Fourth week

Animal was bearing weight on the operated limb and could stand up Favouring of the limb and limping were not seen Nodding was seen while walking fast

Fifth week

Animal was able to get up lie down and walk normally Favouring of the limb and limping were not noticed

Sixth week

Animal could get up lie down and walk normally

The animal was sacrificed on the 42nd day On removing the plaster cast the skin wound at the fracture site was found to have healed The right metacarpus was dissected out There was a well formed callus and there was no mobility of the fragments Angulation was observed at the fracture site

PLASTER CAST

The plaster cast remained intact throughout the period of observation. It had to be reinforced by the end of fourth week as it developed cracks.

RADIOGRAPHIC OBSERVATION

First day Fragments were in apposition with slight posterior deviation of the distal fragment. Fracture line was distinct.

First week Fragments were in apposition with slight posterior deviation of the distal fragment. There was callus formation at the fracture site on both proximal and distal fragments. Fracture line was distinct.

Second week Fragments were in apposition. Displacement and slight posterior deviation of the distal fragment were noticed. More marked callus formation was noticed on both the fragments. Fracture line was distinct.

Third week Fragments were in apposition. Displacement and marked posterior deviation of the distal fragment were noticed. The callus was well developed and there were signs of ossification. Fracture line was partially obliterated (Fig 22)

Fourth week Fragments were in apposition Displacement and marked posterior deviation of the distal fragment were noticed The ossification of the callus was observed and present on both the fragments Fracture line was partially obliterated (Fig 23)

Fifth week Fragments were in apposition Displacement and marked posterior deviation of the distal fragment were noticed The callus was well developed and fracture line was partially obliterated

Sixth week Fragments were in apposition Displacement and marked posterior deviation of the distal fragment were noticed There was angulation of the bone at the fracture site Extensive ossification of the callus was noticed involving both the fragments The fracture line was partially obliterated

Radiograph of the harvested bone Fragments were in apposition Displacement and marked posterior deviation of the distal fragment was noticed resulting in angulation of the bone at the fracture site Well developed osseous callus involving both the fragments was present with partial obliteration of the fracture line

Fig 23 - Radiograph of the right metacarpus four weeks after application of plaster cast. Well developed callus with osseous union near the fracture site.

Fig 24 - Radiograph of the right metacarpus five weeks after application of plaster cast. Extensive osseous callus formation involving both the fragments.



HISTOLOGICAL OBSERVATION

There was extensive proliferation of the periosteum with bundles of connective tissue between the new bone trabeculae Well developed ossified periosteal callus was present adjacent to the cortical bone The internal callus was well developed

ANIMAL NO B/IV

CLINICAL SIGNS

First week

Animal could stand up and lie down without assistance But it could not bear weight on the operated limb It was reluctant to walk There was favouring of fractured limb Limping was noticed when forced to walk Oedema was not observed proximal or distal to the plaster cast

Second week

Animal could get up and lie down without assistance It could not bear weight on the operated limb It was reluctant to walk There was favouring of the fractured limb Nodding dragging of the toes and limping were noticed when forced to walk The skin wound at the sham operation site had healed up and sutures were removed on the 10th day

Third week

Animal could get up lie down and walk without assistance It could not bear weight on the fractured limb There were favouring of the limb dragging of the toes limping and nodding

Fourth week

Animal could get up lie down and walk normally It could not bear weight on the fractured limb Favouring of the limb and nodding were noticed Limping and dragging of the toes were not observed

Fifth week

Animal could get up lie down and walk without assistance It could bear weight on the fractured limb Favouring of the limb and nodding were less marked

Sixth week

Animal could get up lie down and walk normally It could bear weight on the operated limb

The animal was sacrificed on the 42nd day On removing the plaster cast the skin wound at the fracture site was found to have healed up The right metacarpus was dissected out There was a well developed callus and there was no

mobility of the fragments Slight posterior deviation was observed at the fracture site

PLASTER CAST

The plaster cast remained intact throughout the period of observation

RADIOGRAPHIC OBSERVATIONS

First day Fragments were in apposition The fracture line was distinct

First week Fragments were in apposition with slight posterior deviation and anterior displacement of the distal fragment Fracture line was distinct

Second week Fragments were in apposition with slight posterior deviation and anterior displacement of the distal fragment Callus formation was noticed on both the fragments near the fracture site The fracture line was distinct

Third week Fragments were in apposition with slight posterior deviation and anterior displacement of the distal fragment Callus had become more marked near the fracture site and the fracture line was distinct

fourth week Fragments were in apposition with slight posterior deviation and anterior displacement of the distal fragment There was well developed callus with ossification near the fracture site Partial obliteration of the fracture line was noticed

Fifth week Fragments were in apposition with slight posterior deviation and anterior displacement of the distal fragment There was extensive osseous callus formation involving the fragments Partial obliteration of the fracture line was noticed

Sixth week Fragments were in apposition with slight posterior deviation and anterior displacement of the distal fragment There was extensive osseous callus formation involving both the fragments Fracture line was partially obliterated

Radiograph of the harvested bone Fragments were in apposition with slight posterior deviation and anterior displacement of the distal fragment There was extensive osseous callus formation involving both the fragments Fracture line was partially obliterated

HISTOLOGICAL OBSERVATIONS

There was extensive proliferation of the periosteum with bundles of connective tissue between the new bone trabeculae Well developed subperiosteal external callus was observed The internal callus was well developed

ANIMAL NO B/V

CLINICAL SYMPTOMS

First week

Animal could get up and lie down with difficulty and evinced pain It was reluctant to walk and could not bear weight on the fractured limb There was favouring of the fractured limb Limping and nodding were observed

Second week

By early second week animal could get up, lie down and walk without pain It could not bear weight on the fractured limb Favouring of the fractured limb limping stumbling and nodding were observed The skin wound at the sham operation site had healed up and the sutures were removed on the 10th day

Third week

Animal could get up and lie down without difficulty
It could not bear weight on the fractured limb Favouring
of the limb limping stumbling and nodding were noticed

Fourth week

Animal could not bear weight on the fractured limb
Favouring of the fractured limb limping and nodding were
observed Stumbling was less marked There was an increase
in the slope of the pastern of the left fore limb

Fifth week

Animal could not bear weight on the fractured limb
There was favouring of the fractured limb Nodding and
limping were seen There was further increase in the slope
of the pastern of the left fore limb

Sixth week

Animal could bear weight on the fractured limb
partially Favouring of the fractured limb was observed
Limping and nodding were not noticed There was marked
increase in the slope of the pastern of the left fore limb

The animal was sacrificed on the 42nd day On
removing the plaster cast the skin wound at the fracture

site was found to have healed The right metacarpus was dissected out There was a well formed callus and there was no mobility of the fragments There was slight deviation at the fracture site

PLASTER CAST

The plaster cast remained intact throughout the period of observation

RADIOGRAPHIC OBSERVATIONS

First day Fragments were in apposition The fracture line was distinct

First week Fragments were in apposition with slight displacement and posterior deviation of the distal fragment Fracture line was distinct

Second week Fragments were in apposition with slight displacement and posterior deviation of the distal fragment Callus formation was noticed on the distal fragment near the fracture site The fracture line was distinct

Third week Fragments were in apposition with slight displacement and posterior deviation of the distal fragment Callus formation was more marked and was involving both the fragments Fracture line was distinct

Fourth week Fragments were in apposition with slight displacement and posterior deviation of the distal fragment Callus formation was more marked and fracture line was distinct

Fifth week Fragments were in apposition with slight displacement and posterior deviation of the distal fragment Callus formation was more marked near the fracture site and the fracture line was partially obliterated (Fig 24)

Sixth week Fragments were in apposition with slight displacement and posterior deviation of the distal fragment There was well developed osseous callus involving both the fragments There was partial obliteration of the fracture line (Fig 25)

Radiograph of the harvested bone Fragments were in apposition with slight displacement and posterior deviation of the distal fragment Well developed osseous callus was noticed involving both the fragments There was partial obliteration of the fracture line (Fig 26)

HISTOLOGICAL OBSERVATIONS

There was extensive proliferation of the periosteum with formation of well developed calcified periosteal callus in continuation with cortical bone Bundles of

Fig 25 - Radiograph of the harvested right metacarpus six weeks after application of plaster cast
Extensive ossified callus with partial obliteration of the fracture line

Fig 26 - Radiograph of the harvested right metacarpal bone Group B) Specimen harvested at, two weeks(2) four weeks(4) and six weeks(6)



connective tissue were seen between the new bone trabeculae
The internal callus was well developed

ANIMAL NO B/VI

CLINICAL SYMPTOMS

First week

Animal could get up and lie down without assistance
But it evinced pain It could not bear weight on the
fractured limb Favouring of the limb and nodding were
observed By the end of the week signs of pain were not
observed

Second week

Animal could get up, lie down and walk without
assistance It could not bear weight on the fractured limb
Favouring of the limb limping and nodding were noticed
Stumbling of the fractured limb was seen while walking fast
The skin wound at the sham operation site had healed and
sutures were removed on the 10th day

Third week

Animal could get up lie down and walk without
assistance It could not bear weight on the fractured limb

Favouring of the fractured limb limping and nodding were observed Stumbling was noticed only when forced to walk fast

Fourth week

Animal could get up and lie down without assistance It could bear weight on the fractured limb It exhibited pawing action with the fractured limb Favouring of the limb and nodding were not seen

Fifth week

Animal was able to stand up and walk normally The pawing action persisted There was no limping during progression

Sixth week

Animal was able to stand up and walk normally Pawing action was observed

The animal was sacrificed on the 42nd day On removing the plaster cast the skin wound at the fracture site was found to have healed The right metacarpus was dissected out There was a well formed callus and there was no mobility of the fragments

PLASTER CAST

The plaster cast remained intact throughout the period of observation

RADIOGRAPHIC OBSERVATIONS

First day Fragments were in apposition The fracture line was distinct

First week Fragments were in apposition with slight displacement of the distal fragment The fracture line was distinct

Second week Fragments were in apposition with slight displacement of the distal fragment There was callus formation on the distal fragment near the fracture site The fracture line was distinct

Third week Fragments were in apposition with slight displacement of the distal fragment There was marked callus formation on the distal fragment The fracture line was distinct

Fourth week Fragments were in apposition with slight displacement of the distal fragment Callus formation was involving both the fragments The fracture line was distinct

Fifth week Fragments were in apposition with slight displacement of the distal fragment There was marked callus formation involving both the fragments There was partial obliteration of the fracture line

Sixth week Fragments were in apposition with slight displacement of the distal fragment There was well developed osseous callus involving both the fragments at the fracture site Partial obliteration of the fracture line was noticed

Radiograph of the harvested bone Fragments were in apposition with slight displacement of the distal fragment There was well developed osseous callus involving both the fragments at the fracture site Partial obliteration of the fracture line was noticed

HISTOLOGICAL OBSERVATIONS

Well developed ossified external callus was present It showed areas of fibrocartilage with bundles of collagen in between The cartilage showed signs of ossification at the periphery The internal callus was well developed

From the foregoing findings, it could be observed that,

Sedation with triflupromazine hydrochloride at the rate of 0.25 mg/kg body weight IM and diazepam at the rate of 0.20 mg/kg body weight IV, followed by local infiltration analgesia using two per cent solution of lignocaine hydrochloride was satisfactory for the surgical manipulations

Resection of periosteum over the metacarpus could be done after incising it longitudinally and separating it from the underlying cortical bone. Continuous lock stitch using 1/0 silk was placed on the periosteal incision. On cropping the metacarpus at varying periods of the experiment, the periosteum had united firmly.

A Clinical findings

- 1 All the animals except B/II could get up and lie down without difficulty during the first and second weeks
- 2 Pain while walking was ^{observed} only in B/V and B/VI during the first week
- 3 The animal B/III started bearing weight on the operated limb from the third week, B/VI from the fourth week and B/IV from the fifth week. Animals B/II, B/I and B/V in

4

which the period of observation was two weeks, four weeks and six weeks respectively, did not bear weight during the period

- 4 Favouring the fractured limb was observed in all the animals except B/II In animal B/III it was not noticed from the third week onwards and in B/VI from the fourth week onwards
- 5 Nodding of the head and limping were observed throughout the period of observation in B/IV and B/V upto the fifth week in B/VI and upto the third week in B/I and B/III
- 6 Stumbling was observed during the first three weeks in animal B/VI and during the first four weeks in B/V
- 7 Dragging of the toes was observed during the first three weeks in B/IV
- 8 Pawing with the fractured limb was observed throughout the period of observation of four weeks in B/I and from the fourth week in B/VI
- 9 Increase in the slope of the pastern of the left forelimb was observed in animal B/V from the fourth week

B Plaster cast

In all the animals plaster cast remained intact throughout the period of observation A few cracks were noticed at the distal and proximal ends but did not affect the stability of the cast

C Radiographic findings

- 1 In all the animals slight displacement of the fragments was observed from the first week onwards but the apposition was satisfactory throughout the period of observation except in B/II Marked posterior deviation of the distal fragment was noticed in B/III resulting in angulation of the bone at the fracture site Slight deviation was observed in B/I B/IV and B/V

- 2 Radiographically visible callus was noticed by the first week in animal B/III and by the second week in rest of the animals

- 3 The fracture line became partially obliterated by the end of third week in B/III fourth week in B/I and B/IV and by the fifth week in B/V and B/VI

Fig 27 - Bones cropped in Group B Dorsal view Six
weeks for weeks and two weeks after
immobilization

Fig 28 - Bones cropped in Group B - Lateral view Six
weeks four weeks and two weeks after
immobilization

G7



4 w



2 w

4 w



4



2 w

D Gross findings of the callus

The harvested right metacarpus showed well developed callus formation bridging the fragments. There was no mobility of the fragments except in B/II in which the period of observation was two weeks (Fig 27 & 28)

E Histological findings

Second week

Extensive external callus formation was observed. There was organisation of blood clot between the periosteum and cortical bone. Proliferation of the connective tissue with osseous trabeculae formation was noticed in the callus (Fig 29 & 30)

Fourth week

There was proliferation of the periosteum (Fig 31). The callus showed zones of newly formed connective tissue. Hypertrophied cartilage cells with ossification at the periphery of the cartilage (Fig 32) was also observed. New trabecular bone was seen extending from the surface of the cortical bone into the callus.

Sixth week

There was well developed subperiosteal external callus. In all the animals extensive trabecular new bone

Fig 29 Photomicrograph of the callus at two weeks in Group B Showing organisation of subperiosteal blood clot and external callus formation

Fig 30 Photomicrograph of the callus at two weeks in Group B Showing extensive subperiosteal connective tissue proliferation



Fig 31 - Photomicrograph of the callus at four weeks in Group B showing extensive periosteal reaction

Fig 32 - Photomicrograph of the callus at four weeks in Group B Showing cartilage formation with signs of ossification at the periphery

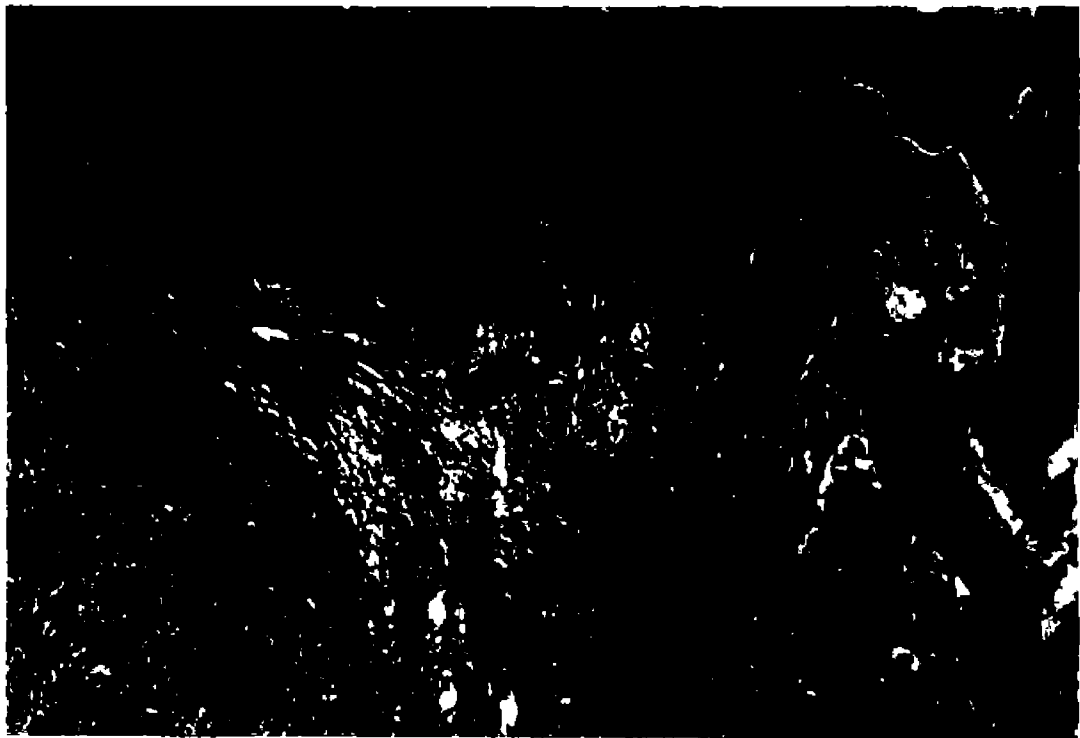


Fig 33 Photomicrograph of the callus at six weeks in Group B showing hyaline cartilage formation

Fig 34 Photomicrograph of the callus at six weeks in Group B showing fibro artilage formation

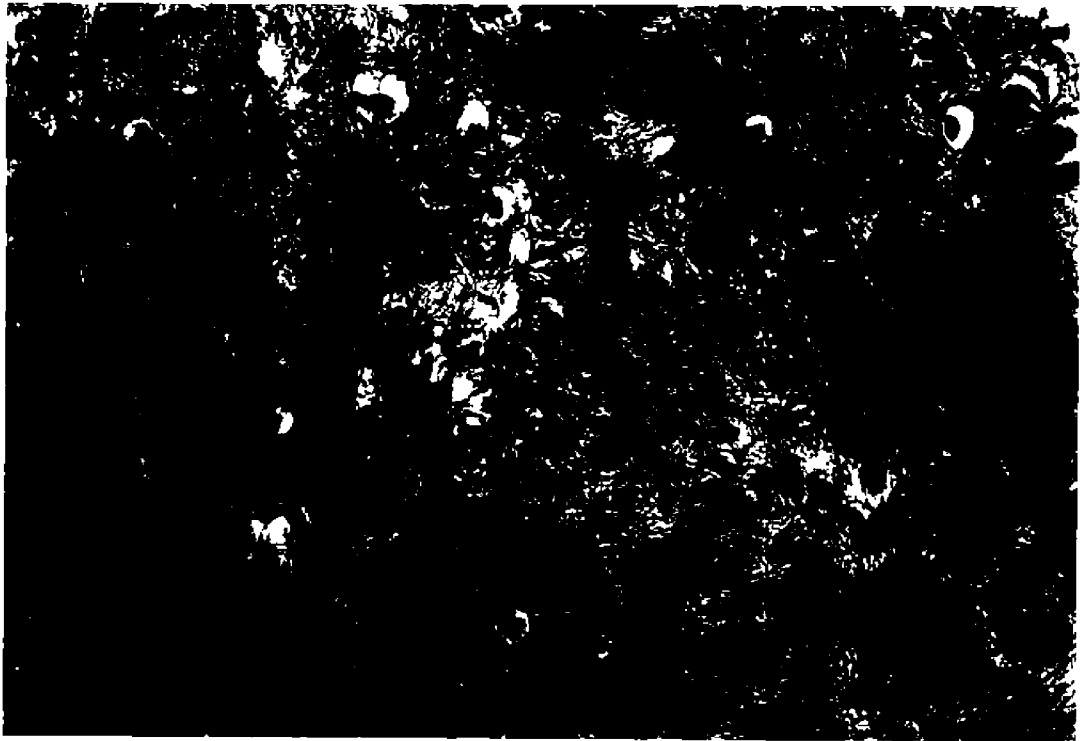
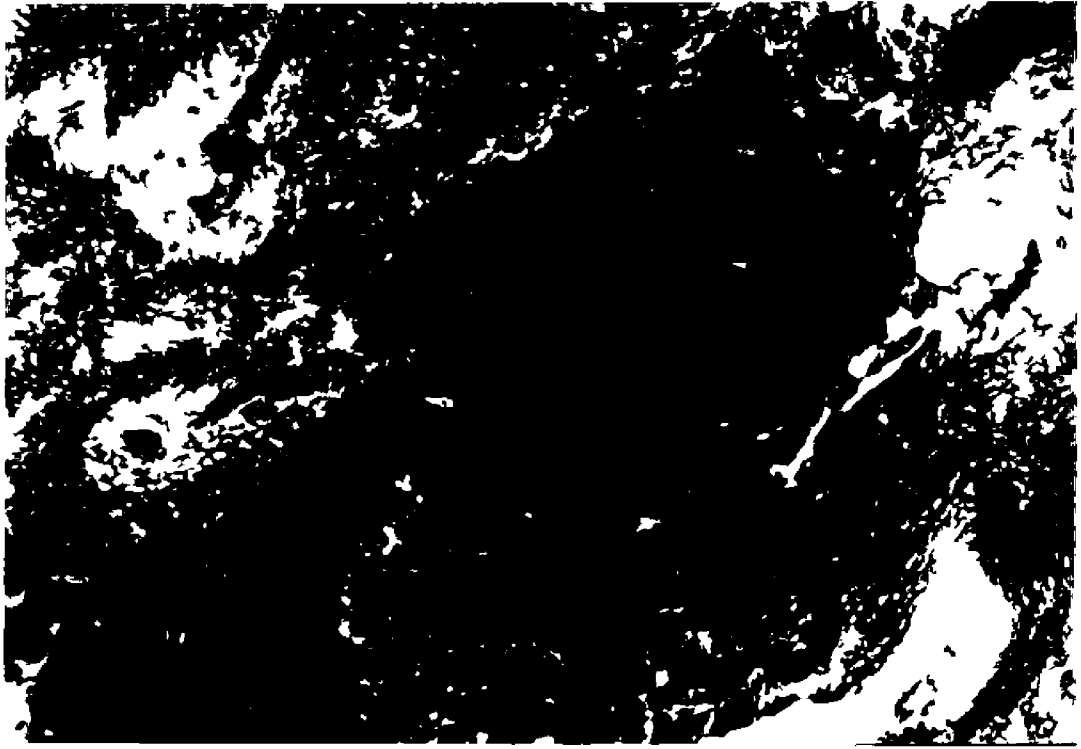


Fig 35 Photomicrograph of the callus at six week in
Group B Showing well developed internal callus



formation and connective tissue proliferation were noticed within the callus. In animal B/VI there were zones of hyaline cartilage (Fig 33) and fibrocartilage (Fig 34) along with zones of ossification. Well developed internal callus formation as noticed in the medullary cavity (Fig 35)

F Sham operation

The wound at the site of sham operation had healed up uneventfully. All sutures were removed on the 10th postoperative day.

Discussion

DISCUSSION

The experimental study was conducted on 12 apparently healthy crossbred male calves aged six to twelve months and weighing 50 to 80 kg. The animals were divided into two groups viz. A and B consisting of six animals each. Sedation with triflupromazine hydrochloride at the rate of 0.25 mg/kg body weight IM and diazepam at the rate of 0.20 mg/kg body weight IV followed by local infiltration analgesia using 1.0 per cent solution of lignocaine hydrochloride was satisfactory for the surgical manipulations. A complete transverse midshaft fracture was created on the right metatarsal of Group A. The fracture was reduced and two fresh autogenous rib grafts were fitted on to the fracture subperiosteally using the cerclage wiring. External immobilisation was achieved by means of four cotton padded bamboo splints and plaster of Paris cast. In Group B the fracture was reduced and the limb was immobilized with four cotton padded bamboo splints and plaster of Paris cast.

Clinical Symptoms

By the second week all the animals could be up and able to bear weight.

Two animals of Group A and three animals of Group B did not bear weight during the period of observation. Four

animals of Group A and three animal of Group B started bearing weight on the fractured limb from varying periods

Favouring of the fractured limb was observed in all the animals however it disappeared in two animals of Group A and two animal of Group B from the later half of the period of observation

Nodding of the head and limping were observed in all the animals of Group A and B however it disappeared at varying periods in a few animals

Stumbling and painful action with the fractured limb was observed in two animal of group A and in two animals of group B

Dragging of the toes was observed only in one animal in Group B

Increase in the slope of the pastern of the left forelimb was observed in two animals of Group A and one animal of Group B

Ayyappan et al observed anorexia in all the animals during the period of observation of six weeks and has recorded that it took 10 to 30 days for the animals to bear weight on the fractured limb after the treatment (Kumar et al 1983) observed prolonged lameness with simple

coaptation in comparison with stable fixation such as K nailing and double plate fixation. Biswas (1990) compared different external immobilization techniques and observed that animals could get up and lie down without assistance and a satisfactory functional restoration of the operated limb was achieved by 30 days when it was treated either with stainless steel plates or iron plates.

Infection and suppuration at the suture line was observed in one animal (A/I) from the first week. However, the infection did not extend into the allusion. Chant et al (1970) and Singh et al (1984) and Rao et al (1985) reported that non-union and malunion were the most common postoperative complications after external and internal immobilization of fractures in animals.

Plaster cast

The plaster of Paris cast was removed after the period of observation. In all the animals of both the groups reinforcement of the plaster cast was done in a few animals. In both the groups the necessity of plaster of Paris cast as external support for effective immobilization is recommended. In the study of Singh et al (1975) and Rao et al (1978) and Rao et al

/III and V a t e f f t e e k I and I
 Group B ev lence of osseous callus formation was obser e
 by t e f r s k n III and b t c second ee in r st f
 t e an al esent stu y cal us format on
 observed t o e c k s n a l t h e a n a l of Gro
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 fragment at th f a t u r e s i t e r e s u l t e d i n t c format o
 a fibrou c l l b s e n t o f o u r t e e n d a

Par a on of t fracture ap as ob r
 by th n of t o r t e k n \I an A VI and b t e
 end of the f f e n i m a l s A / I a n d A I V I n Gro p
 partial obliteration of the fracture gap was obser ed by t e
 end of third we k i n B / I I I b y t h e e n d o f t h o u r t w e e k
 /I an an t e e n d o f t h e f i f t h e e k n B n
 B / V I C o m p l e t e o b s e r v a t i o n a s n o t o b s e r v e d i n a n o t h e
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 c l i n i c l b l

and ossification of external and internal callus with transfixation pinning. With simple coaptation the callus was characterised by zones of hyaline cartilage among areas of ossification. Braden and Brinker (1976) opined that cartilage formation occurs whenever cellular proliferation outpaces vascular regeneration and that the differentiation of the primordial callus depended on the rigidity of immobilisation provided to the fragments. Rao (1981) observed that the internal callus was predominantly chondroosteoid with simple coaptation and osteoid when bone plates were used.

Gertsen and Brinker (1969) stressed the necessity of good plaster of paris cast along; it bone plating Hoffman (1956) and undvall (1960) observed that plaster of paris cast supports splints was a satisfactory method of immobilization.

Radiographic observations

In all the animals slight displacement of the distal fragment was observed from the first week onward. The apposition was satisfactory throughout the period of observation except in A/V and B/II. In these two animals wherein the period of observation was only for two weeks marked displacement of the distal fragment was noticed resulting in complete apposition. Marked posterior deviation of the distal fragment was noticed in A/I and B/III resulting in angulation of the bone at the fracture site. Slight deviation of the distal fragment at the fracture site was observed in B/I, B/IV and B/V.

Grafts were in position in all the animals throughout the period of observation. The grafts could not be differentiated in radiographs by the sixth week in A/I by fifth week in B/II and by the fourth week in B/VI.

Radio-graphic evidence of osseous callus formation was observed by the third week in A/I by the fourth week in

Gross Specimen

The metacarpus cropped after two weeks of observation showed development of callus at the site of fracture but there was mobility between the fragments. In the animals kept under the observation for four weeks and six weeks the cropped metacarpus showed well developed callus uniting the fragments and there was no mobility between the fragments suggesting clinical union of the fracture. The callus developed at the end of four weeks as comparable to the callus developed at the end of six weeks. Winstanley (1974) observed that application of pressure at the fracture site provided rigid fixation resulting in direct bony union with formation of minimum periosteal callus. Bloom and Mentstegge (1980) reported that stable fixation caused reduced periosteal callus formation. Singh (1977) found that in the case of inadequate immobilization increased extraosseous circulation persisted for longer duration as the medullary circulation could not be re established across the fracture gap due to the continued movements and resulted in bigger external callus with radioluscent gap between the fragments. Ackerman and Silverman (1978) observed that radiographic healing occurred long after a fracture had healed clinically.

Histological find

Histological examination of the callus cropped at the second week in Group A revealed periosteal and capillary proliferation along with inflammatory reaction around the graft. The trabecular bone formation as noticed at the periphery of the graft. In group B there was organisation of clot under the periosteum with proliferation of connective tissue and formation of osseous trabeculae in the callus. Biswas (1990) observed periosteal and capillary proliferation adjacent to the fracture site along with zones of ossification of the callus.

The callus cropped at the fourth week in group revealed extensive areas of graft vascularisation and zones of new bone formation around it. Periosteal new bone formation also was noticed. Focal area of necrosis of the cortical bone was noticed in the tissue. The group specimens revealed extensive subperiosteal callus with zones of connective tissue proliferation and cartilage along with trabecular new bone formation. Biswas (1990) found extensive ossification with trabecular formation and areas of fibrous tissue and inflammation with transfixation pins and marked connective tissue and capillary proliferation with single coaptation. Braden and Brinker (1976) observed that if there is adequate blood

supply at the site of fracture site fibrous tissue would be laid down and if the callus was growing faster than the blood supply cartilage tissue would be laid down. Ulema et al and Kulkarni (1992) observed deposition of osteoid matrix by osteoblasts establishment of Haversian system and marked proliferation of osteoblasts and osteoclasts by 28th day while Bisla et al (1991) observed establishment of Haversian system and trabecular bone. New trabecular formation was seen extending from the surface of the cortical bone. Khan and Ahmed (1977) had observed bone formation encroaching from the host bed to the graft.

In those animals of Group A kept under observation for six weeks the callus was characterised by extensive new bone formation adjacent to the graft and the cortical bone. The callus showed replacement of the graft tissue with proliferating blood vessels connective tissue fibres and new osseous trabeculae. Hyaline cartilage was observed in one animal (VI) and local necrosis of cortical bone in two animals (II and A/IV). In Group B extensive periosteal callus along with well developed internal callus was observed with plenty of connective tissue fibres between the trabecular ossification centres. Fibrocartilage was noticed only in one animal (B/VI). Biswas (1990) reported that formation of interconnected osseous trabeculae

and ossification of external and internal callus with transfixation pinning. With simple coaptation the callus was characterised by zones of hyaline cartilage among areas of ossification. Braden and Brinker (1976) opined that cartilage formation occurs whenever cellular proliferation outpaces vascular regeneration and that the differentiation of the primordial cells depended on the rigidity of immobilisation provided to the fragments. Rao (1981) observed the healing callus as predominantly chondro osteoid with simple coaptation and osteoid when bone plates were used.

Summary

SUMMARY

The present study was conducted on 12 apparently healthy crossbred male calves six to twelve months of age and weighing 50 to 80 kg divided into two groups of six animals each (Group A and B). A transverse mid shaft fracture was created on the right metacarpus by open method, under sedation with Triflupromazine hydrochloride at the rate of 0.25 mg/kg body weight IM and diazepam at the rate of 0.20 mg/kg body weight IV followed by local infiltration analgesia using two per cent solution of lignocaine hydrochloride.

In group A the fracture was reduced and the fragments were retained in position by placing two freshly cropped autogenous rib grafts subperiosteally, one on the anterior aspect and the other on the posterior aspect of the metacarpus. The grafts were fixed in position by hemicerclage wiring using stainless steel wires at two places. The limb was immobilized with four cotton padded bamboo splints and plaster of paris cast. In group B the fracture was reduced and the wounds were sutured. The limb was immobilised with four cotton padded bamboo splints and plaster of paris cast.

A sham operation was performed on the left metacarpal region on the same day by incising the skin upto the periosteum and suturing it.

By the end of the second week all the animals could get up and lie down without assistance

Two animals of Group A and three animals of Group B did not bear weight during the period of observation Four animals of Group A and three animals of Group B started bearing weight on the fractured limb from varying periods

Favouring of the fractured limb limping and nodding of the head were observed in all the animals

Pawing with the fractured limb and stumbling were observed in two animals each from both the groups

Dragging of the toes was observed only in one animal, in group B

Infection and suppuration at the suture line was observed in one animal of group A

Plaster of paris cast remained intact throughout the period of observation in all the animals One animal from group A and four animals from group B required reinforcement of plaster cast

Marked displacement of the distal fragment was noticed in one animal each in Group A and B But deviation of the

distal fragment at the fracture site was observed in one animal of Group A and four animals of Group B

Grafts were in position in all the animals throughout the the period of observation. They became radiographically indistinguishable from fourth week onwards

Radiographically visible callus was found by the third week in group A and by the first week in group B

Partial obliteration of the fracture gap was observed by the end of fourth week in both the groups

Fractured bone cropped after two weeks revealed mobility between the fragments in both the groups. The bones cropped after four weeks showed well developed callus uniting the fragments and there was no mobility at the fracture site in both the groups. The callus developed at the end of six weeks and four weeks were grossly similar in both the groups

Histological examination of the callus cropped at second week in group A revealed periosteal and capillary proliferation along with new trabecular bone formation around the graft site. In group B fibrous tissue proliferation exceeded trabecular new bone formation

Replacement of the graft tissue with proliferating blood vessels osseous tissue and connective tissue were observed in the callus cropped from the animals of group A at the end of six weeks In group B well developed internal callus extensive periosteal callus proliferation of fibrous tissue and trabecular ossification centres were observed Fibrocartilage was noticed in the callus in one animal of group B

From the results of the present study it could be concluded that

- 1 Autogenous rib grafts were satisfactory for the immobilisation of fracture of metacarpus in calves
- 2 The autogenous rib grafts were gradually replaced in the process of healing indicating that the graft was readily accepted
- 3 Autogenous rib grafts with external immobilisation was better than splints and plaster cast alone for the immobilisation of fracture of metacarpus in calves

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TREATMENT OF FRACTURE OF METACARPUS IN CALVES USING AUTOGENOUS RIB GRAFT

By

SYAM K. VENUGOPAL

ABSTRACT OF A THESIS

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Master of Veterinary Science

Faculty of Veterinary and Animal Sciences
Kerala Agricultural University

Department of Surgery

COLLEGE OF VETERINARY AND ANIMAL SCIENCES
Mannuthy Thrissur

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ABSTRACT

The present study was conducted on 12 apparently healthy, crossbred male calves six to twelve months of age and weighing 50 to 80 kg divided into two groups of six animals each (Group A and B). A transverse mid shaft fracture was created on the right metacarpus by open method under sedation with Triflupromazine hydrochloride at the rate of 0.25 mg/kg body weight IM and diazepam at the rate of 0.20 mg/kg body weight IV followed by local infiltration analgesia using two per cent solution of lignocaine hydrochloride.

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A sham operation was performed on the left metacarpal region on the same day by incising the skin upto the periosteum and suturing it.

By the end of the second week all the animals could get up and lie down without assistance

Four animals of Group A and three animals of Group B started bearing weight on the fractured limb from varying periods

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The callus cropped at fourth week in group A revealed extensive areas of graft vascularisation and zones of new bone formation. In group B cartilage formation was seen along with zones of new bone formation and fibrous tissue proliferation.

Replacement of the graft tissue with proliferating blood vessels, osseous tissue and connective tissue were observed in the callus cropped from the animals of group A at the end of six weeks. In group B well developed internal callus, extensive periosteal callus, proliferation of fibrous tissue and trabecular ossification centres were observed. Fibrocartilage was noticed in the callus in one animal of group B.