COMPARATIVE STUDY OF HEALING OF FRACTURE OF METACARPUS IN CALVES USING DIFFERENT EXTERNAL IMMOBILISATION METHODS

By

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THESIS

Submitted in partial fulfilment of the requirement for the degree

Master of Veterinary Science

Faculty of Veterinary and Animal Sciences
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Department of Surgery
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1990

DECLARATION

I hereby declare that this thesis entitled COMPARATIVE STUDY OF HEALING OF FRACTURE OF METACARPUS IN CALVES USING DIFFERENT EXTERNAL IMMOBILISATION METHODS is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma associateship fellowship or other similar title of any other University or Society

Mannuthy
24th August 1990

Kalyani Biswas

CERTIFICATE

Certified that this thesis, entitled COMPARATIVE STUDY OF HEALING OF FRACTURE OF METACARPUS IN CALVES USING DIFFERENT EXTERNAL IMMOBILISATION METHODS is a record of research work done independently by Kum Kalyani Biswas under my guidance and supervision and that it has not previously formed the basis for the award of any degree fellowship or associateship to her

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Introduction

INTRODUCTION

Incidence of fracture of long bones in cattle in India has not been adequately documented so far However available literature indicate that the incidence is high Mohanty (1970) and Pietal (1971) have reported that the incidence of fractures of metacarpal and metatarsal bones in cattle is considerable

During recent years, there has been greater demand for orthopaedic procedures in large animal practice Long bone fractures of cattle heal rapidly and remarkably well provided alignment and fixation are achieved (Walker 1979) Efficacy in fracture treatment depends to a great extent on the early adoption of treatment effective apposition and immobilisation and the strength of the immobilising dressing But the heavy weight and size of the adult patient cost of the treatment and rehabilitation of the animal after treatment are deterrants faced by the field veterinarians in adopting the newer orthopaedic procedures in large animals

External ımmobılısatıon usıng plaster of Parıs ıs stıll the most commonly adopted technıque ın large anımal orthopaedıcs though ıt ıs not wıthout complı catıons Modıfıcatıons lıke hangıng pın cast have to a great extent elımınated the possı › lıty of many of the complıcatıons notıced wıth plaster of Parıs cast ın large anımals

The avaılable reports reveal that ınvest gatı › s to fınd a uıtable substıtute to plaster of Parıs cast have not been very successful Hence the present study was undertaken wıth the followıng objectıves

1 To evaluate the efficıency of selected external ımmobılısatıon methods for ımmobılısıng fracture of the large metacarpus ın calves

2 To study the progress of healıng under dıfferent methods of ımmobılısatıon

3 To fınd out a substıtute for plaster of Parıs cast

Review of Literature

REVIEW OF LITERATURE

Kirk (1951) outlined the first aid techniques in fractures in large animals and has opined that plates screws or pins used for immobilisation should not be made to bear weight or stress but should be borne by external splints made of metal or plaster of Paris

Kirk and Fennell (1951) described the treatment of a transverse mid shaft fracture of the os calcis in a bull by internal fixation using two stainless steel plates one superimposed over the other The limb was further immobilised with plaster cast and the recovery was uneventful

Shuttleworth (1951) discussed fractures in large animals its treatment and sequele Treatment of fractures of radius and ulna by plating or using Stader type splint and fractures of metacarpus and metatarsus with gypsona splinting responded well whereas fractures of femur and humerus were more complicated

Kirk (1952) reviewed techniques of fracture immobilisation in large and small animals and reported that appliances used for internal fixation should be reinforced with plaster of Paris cast

Henig and Walker (1954) described an external fixation technique for treatment of mid metatarsal fracture in a colt using four stainless steel pins set at divergent angles held in position with sustaining rods and clamps and supported by plaster cast The recovery was uneventful

Hoffman (1956) recorded successful immobilisation of fracture of the radius in a heifer using plaster of Paris bandages reinforced with splints of plywood

Reichel (1956) compared the efficacy of plaster cast alone and transfixation pinning with plaster cast in the treatment of long bone fractures in 64 large animals All the 21 animals where plaster cast alone was used and 37 of the 43 animals in which transfixation pinning with plaster cast was used recovered without complications

Price (1957) modified the Thomas splint for treating fracture of the left femur in a bull using light

weight aluminium pieces The foot was wired to the foot plate through holes drilled on the hoof wall The animal was ambulatory during the treatment

Beckenhauer (1958) fabricated a metallic Thomas splint for external fixation in large animals and observed complications like pressure necrosis in spite of padding the ring The recovery rate was fifty per cent

Leonard (1960) stated that plaster cast when used for immobilisation in fracture must allow for ample circulation to the part and that oedema can develop because of pressure caused by shrinkage of cotton bandage

Lundvall (1960) evaluated the methods of treatment adopted in 151 cases of fracture of long bones in large animals viz Thomas splints plaster cast intramedullary pins stainless steel plates and screws through and through fixation pins with and without plaster cast and supporting the animal without reduc on He suggested plaster cast supported with metal splints as the most satisfactory for calves but windows in the cast for treat ment of compound fractures weakened the splints Through

and through pinning with stainless steel pins and external bars supported with plaster cast was satisfactory

Jenny (1965) discussed the treatment of open fractures and suggested that the contaminated tissue be debrided and fractures reduced either within six hours or only after the infection had subsided

Mohanty et al (1970) studied the treatment of fractures in 26 experimental and 40 clinical cases in cattle and found that in metatarsal and metacarpal fractures unpadded plaster cast gave satisfactory results They found that after pinning infection was a frequent complication

Pietal (1971) reviewed 269 cases of fractures in cattle and found that 17 per cent of the cases involved the femur 13 per cent the tibia and 11 per cent each involving the large metatarsal and the large metacarpal

Gill and Tyagi (1972) studied the effects of plaster of Paris cast and hanging pin cast with and without Thomas splint for treatment of fractures of long bones in calves They found that coaptation with plaster of

Paris bandages supplemented with aluminium bars to be the simplest and safest technique in calves and that Thomas splint was more useful in heavy animals

Nemeth and Numans (1972) successfully devised a walking frame for treatment of fractures in large animals using Steinmann pins and a U shaped metal frame

Tyagi and Gill (1972) evaluated transfixation and bone plating for fractures of tibia and large metatarsal bones in two groups of buffalo calves Transfixation was found to be useful in the treatment of oblique fractures while bone plating was satisfactory in transverse fractures

Ramkumar et al (1973) treated a case of oblique fracture of tibia in a four year old cow using hanging pin cast but without success

Rao and Rao (1973) used rush pins along with tibial or tarsal splints for immobilisation in ten experimental animals and two clinical cases of fractures of tibia and large metatarsal bone

Connell (1974) adopted transfixation pinning for treatment of fracture of long bones in calves using Kirschner pins driven through and through obliquely and welding the protruded portions on to extension rods kept perpendicular on either side The immobilisation was satisfactory the animals were ambulatory and healing was uneventful

Fessler and Amstutz (1974) reported that swelling proximal and distal to plaster of Paris cast was due to impairment of circulation effected by the cast

Rao (1975) used bamboo splints and gypsona plaster along with short and modified Thomas splints to immobilise fractures of metacarpal and metatarsal bones in adult bovines The immobilisation did not interfere with ambulation and the healing was satisfactory

Sahay and Khan (1976) reported satisfactory results by using self polymerising acrylic agents for external immobilisation with transfixed Steinmann pins in the treatment of fractures of metacarpal and metatarsal bones in 12 buffalo calves

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

Sahu and Baghel (1978) successfully treated a non united fracture of the metacarpus in a cow by onlay bone grafting using preserved autogenous rib fixed in position by a bone staple Autogenous rib chips were also inserted between fractured ends

Singh (1978) evaluated the efficacy of simple coaptation stainless steel plating and homogenous onlay bone plating in treatment of metatarsal fractures in buffalo calves and found mild periosteal reaction by the second week and moderate periosteal reaction with bridging of the fracture gap by the fourth week The fracture gap had further reduced by the sixth week and was almost obliterated by the eighth week

Singh and Nigam (1979) used coaptation splints in the treatment of metatarsal fractures in calves and found slight periosteal reaction and blurring of the fracture gap by the second week periosteal bone formation by the fourth week and well defined periosteal callus bridging

the fracture gap by the sixth week though the fragments were radiographically separate A well organised osseous callus completely bridging the fracture gap was observed by the eighth week Manipulation revealed no mobility of the fragments from the fourth week onwards

Hamilton and Tulleners (1980) treated fracture of tibia in three calves by transfixation pinning Alignment was excellent and the animal was bearing weight on the limb

Ramkumar et al (1980) reviewed the various techniques of treatment for fractures of femur and humerus in adult cattle and recommended the use of K nails instead of Steinmann pins for intramedullary pinning

Sharma et al (1980) studied the effect of time for immobilisation on fracture healing in induced fracture of metatarsus in buffaloes and concluded that the best time for immobilisation of fractures in large animals was around the third day after fracture

Ayyappan (1981) reported that periosteal proliferation was observed as early as the third week when intramedullary pinning was used as the method of

immobilisation in fracture of tibia in calves He reported that displacement of the fragments was a complication in simple coaptation technique

Ramkumar et al (1981) reported the technique of cross pinning in six cases of compound subarticular fractures of long bones in bovine The protruding ends of the pins on each side were bent and plaster cast was applied in a figure of eight fashion In four animals recovery was uneventful

Singh et al (1981) compared the efficacy of K nailing with and without filling the medullary cavity with methyl methacrylate in treatment of fractures of femur in nine goats Methyl methacrylate with a K nail gave better results than fixation with K nail alone

Vijaykumar et al (1982) studied the effect of hanging pin cast Kuntscher nailing single plate fixation and dual plate fixation in fracture of tibia in bovines and concluded that dual plate fixation in combination with a plaster cast was most effective

Rao et al (1983) conducted radiographic evaluation of fracture healing using simple coaptation stainless

steel plates and allogenic onlay bone plates in buffalo calves and found that healing was better when immobilised with metallic plates and onlay bone plates

Rao et al (1984) reported that peripheral vascular supply played a major role in the blood supply during the initial stages of fracture healing

Singh et al (1984) reviewed the postoperative complications in 270 cases of fractures in large animals and found that malalignment and infection were the most common postoperative complications after external and internal immobilisation of fractures

Rao et al (1985) evaluated the efficiency of simple coaptation cortical onlay bone plates and stainless steel plates in the treatment of fractures of metacarpal bone in buffalo calves and reported that simple coaptation was associated with displacement of fragments and delayed union

Saint Jean et al (1985) reported that the prognosis was poor in fractures of femur or humerus whereas it was more favourable in fractures of other bones

Tulleners (1986) successfully treated 22 metacarpal and 11 metatarsal fractures in cattle using felt orthopaedic padding, metal splints and polyurethane resin fibreglass or resin impregnated plaster of Paris cast

Materials and Methods

MATERIALS AND METHODS

The study was conducted on 18 male calves aged between six to twelve months and weighing approximately 50 to 80 kg The animals were kept under observation for a week prior to the experiment Blood and dung samples were examined The animals were dewormed and were kept under identical conditions of feeding and management The animals were divided into three groups of six animals each viz

Group A consisting of six animals numbered serially from A1 to A6

Group B - consisting of six animals numbered serially from B1 to B6

Group C - con isting of six animals numbered serially from C1 to C6

The experimental procedure was to create a midshaft fracture of the left large metacarpal bone and to immobilise the limb as detailed below

In Group A - by the application of splints and plaster of Paris cast

In Group B by the application of transfixation pins and plates and applying plaster cast over it The plates 7 5 cm long 1 cm wide and 2 mm thick were made of cast iron and chromium plated The transfixation pins 6 4 cm long and 4 mm in diameter were made of stainless steel threaded at both the ends and pointed at one end (Fig 1 and 2)

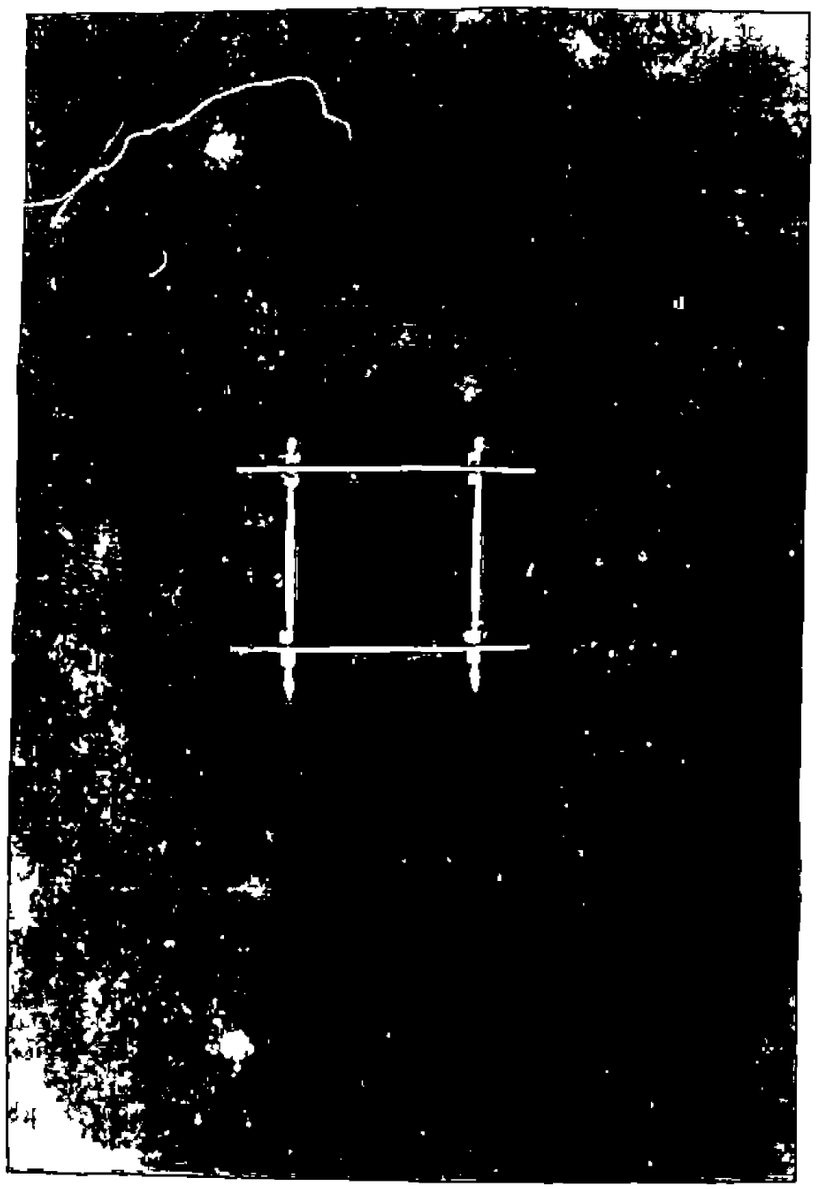
In Group C by the application of splints and bandage impregnated with gum prepared afresh with the following ingredients

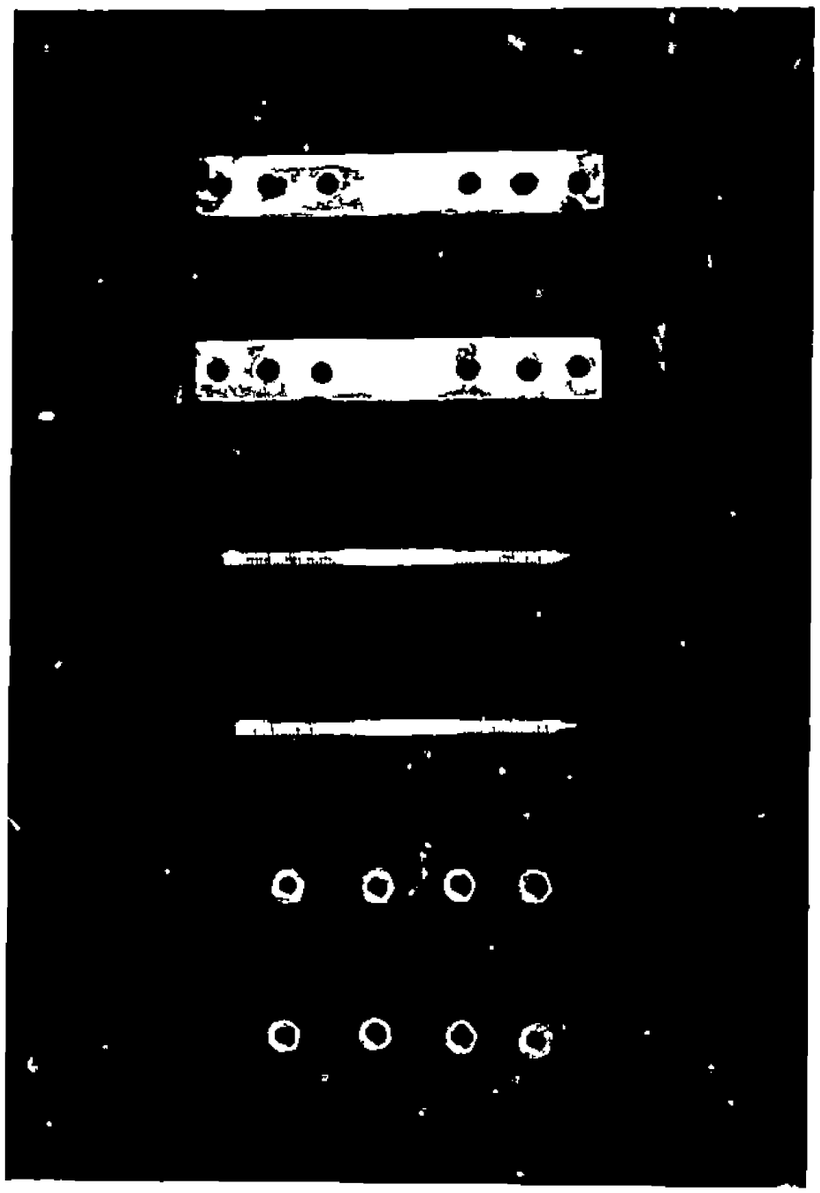
1	Black gram powder	- 125 g
2	Rock salt	- 12 5 g
3	Papadakaram	6 25 g
4	Water	- 25 0 ml
5	Egg white	12 0 ml
6	Lime juice	- 5 0 ml

A dough prepared by mixing black gram powder and the supernatent fluid from the mixture of papadakaram, rock salt and water was procured locally The egg white and lime juice were added to the dough and it was kneaded to prepare the gum

Fig 1 - Component parts of apparatus used for transfixation pinning plates pins and nuts

Fig 2 Transfixation pin assembly





Procedure

Preoperative preparation

All the animals were prepared by withholding feed for 24 hours and water for 12 hours prior to the experiment The entire left forelimb from elbow to foot was washed thoroughly with soap and water The metacarpal region was shaved washed with soap and water and painted with Tr iodine The animals were controlled in right lateral recumbency The limb was suitably draped

Site

Antero lateral aspect of the left metacarpal region

Anaesthesia

The site of operation was anaesthetized by ring block technique Ten millilliters of a two per cent solution of lidocaine hydrochloride* was infiltrated subcutaneously around the limb just below the knee

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* Gesicain SG Pharmaceuticals Baroda

Technique

Group A

A skin incision six centimeters long was made at the midshaft region on the antero-lateral aspect of the metacarpal region The subcutaneous fascia was incised and the bone was exposed by retracting the fascia and the digital extensor tendons Using a sterilized hacksaw blade the bone was cut through half of its thickness and then broken manually to create the fracture

The skin wound was sutured with nylon and polyvinyl polymer spray* was applied over the suture line A piece of sterile gauze was placed over the suture line and bandaged After reduction of the fracture padded bamboo splints of sufficient length were applied and secured in position with tape A plaster of Paris cast was applied over the splints The plaster cast extended from above the knee joint to below the fetlock joint The animals were made to stand after the cast was dry (Fig 3)

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* Healex Rallis India Ltd Bombay

Group B

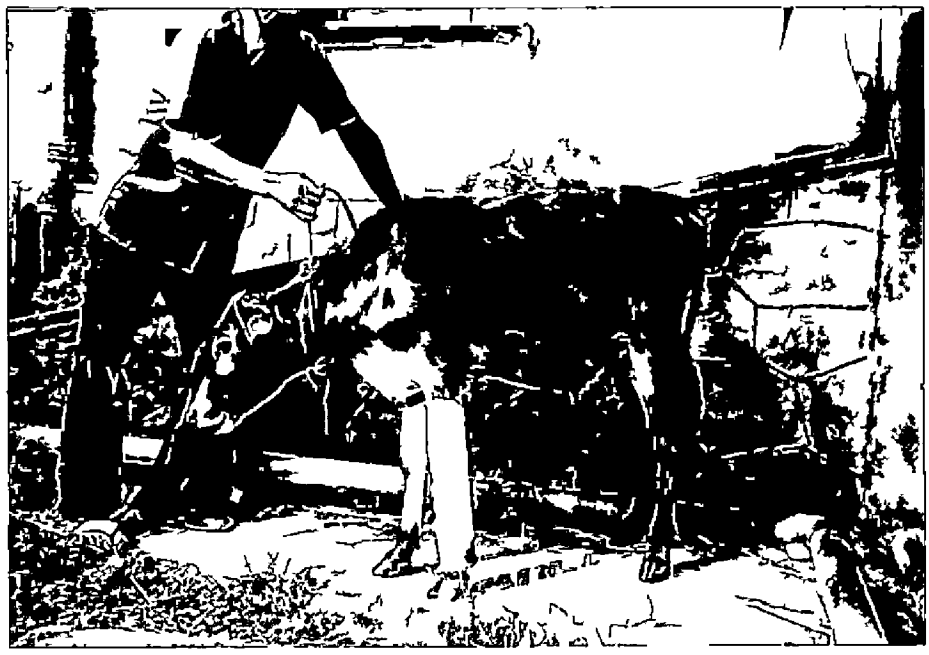
A mid shaft fracture was created and reduced and two holes one on each fragment were drilled transversely from the lateral aspect to the medial aspect of the bone The distance between the holes was adjusted by measuring the distance between the holes in the steel plates The transfixing pins were inserted through the holes in the proximal and distal fragments The skin wound was sutured Keeping the fragments in apposition plates were fixed on to the pins with nuts on either side of the limb The pins and plates were enclosed in a plaster of Paris cast which extended from below the knee to just above the fetlock The animals were supported to standing position after the cast was dry (Fig 4 5 and 6)

Group C

After inducing fracture the skin wound was sutured and a piece of sterile gauze was placed over the suture line The region from the knee to the fetlock was bandaged After reduction of the fracture padded bamboo splints were applied and secured in position using tape The splints were covered with a bandage and a thick layer

Fig 3 - Immobilisation with plaster of Paris cast immed ately after application of the cast

Fig 4 Transfixation pin assembly in position immediately after application Lateral view



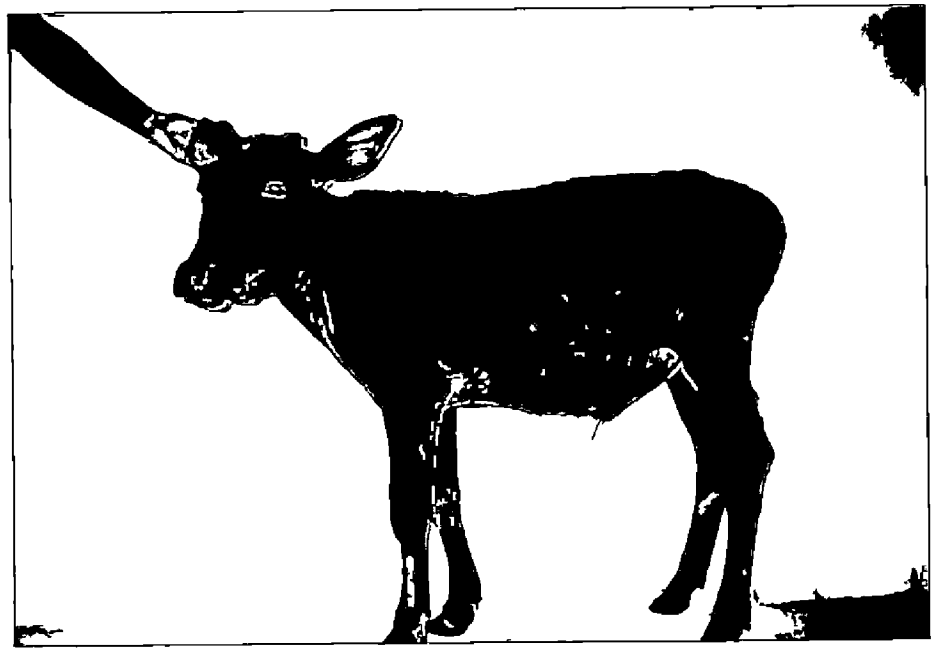
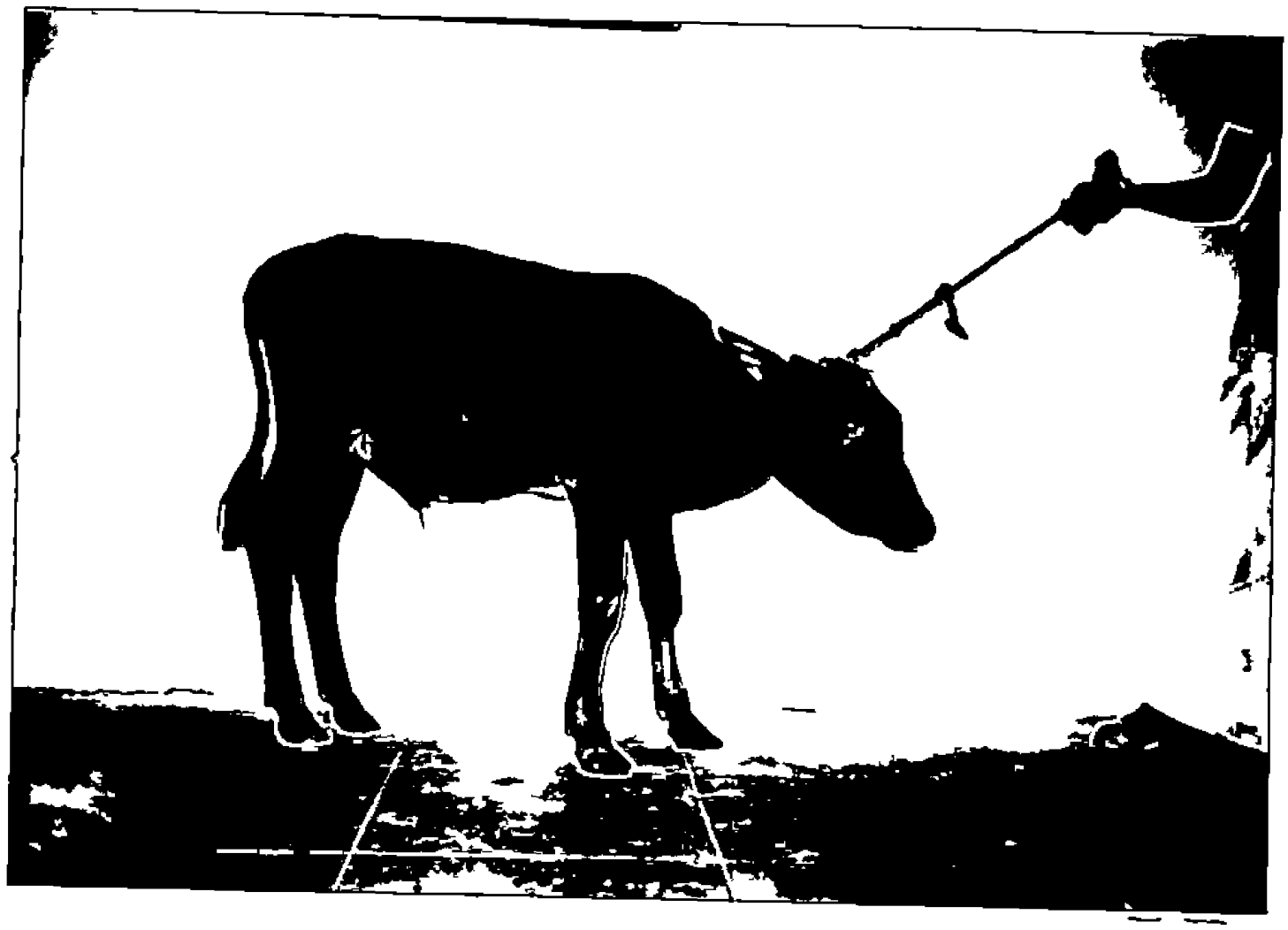
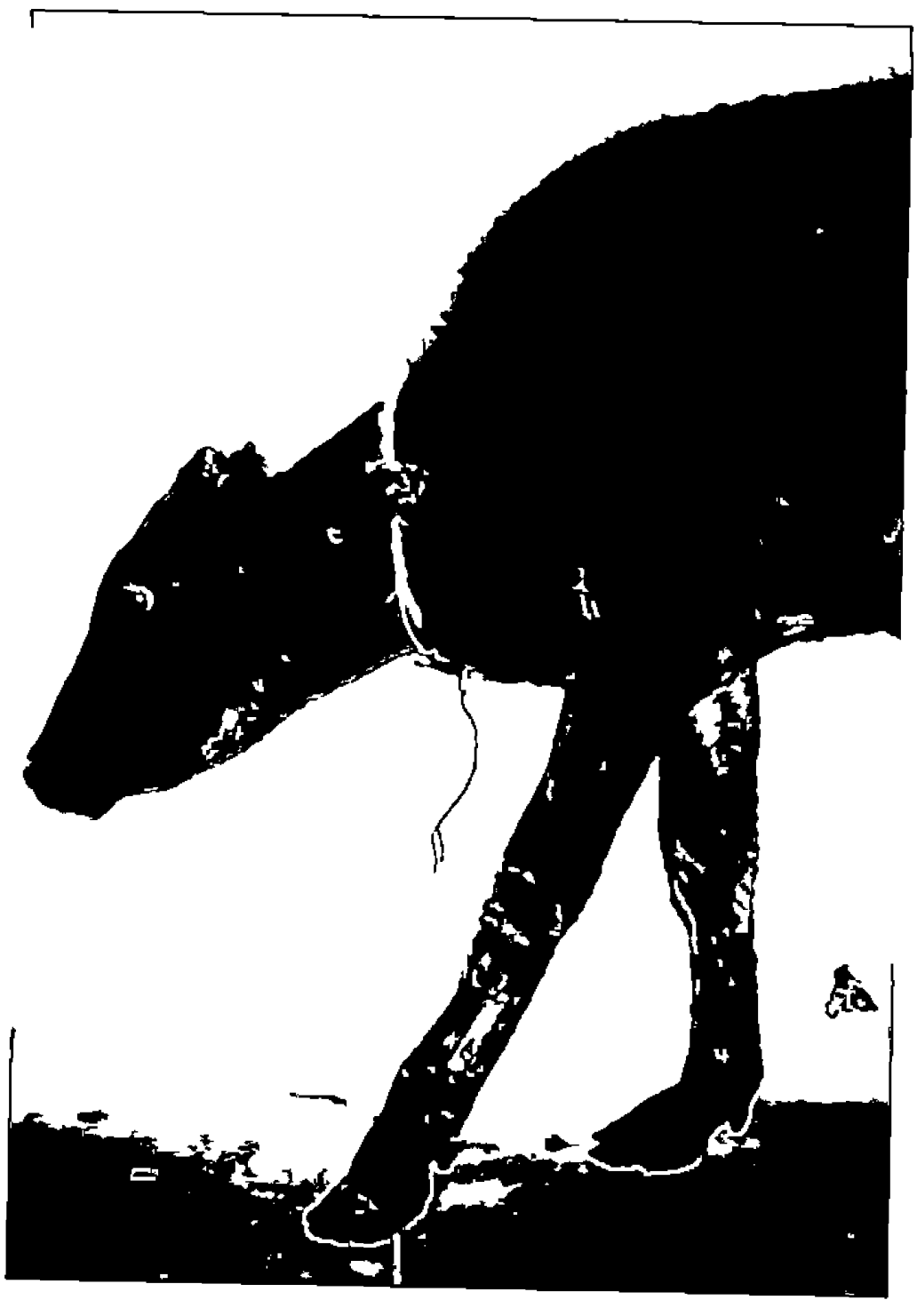


Fig 5 Transfixation pin assembly in position immediately after application medial view

Fig 6 - Transfixation pin assembly in position six weeks after application





of the freshly prepared gum was applied over the bandage A bandage was applied over the gum and the gum was smoothened down in the direction of the bandage Another layer of gum and bandage was applied over this and the cast was allowed to dry The cast extended from just above the knee to below the fetlock The animals were supported to the standing position (Fig 7 8 and 9)

Postoperative care

The animals were kept under observation for periods upto six weeks One calf from each group was sacrificed at two weeks and another from each group at four weeks and the remaining animals (four calves in each group) were sacrificed on completing six weeks The immobilising plaster cast/apparatus/bandage were maintained throughout the period of observation Penicillin (10 lakhs) and Streptomycin (1 25 g) combination* was administered intra muscular for five consecutive days for all the calves Neem oil was applied over the cast in animals of Group

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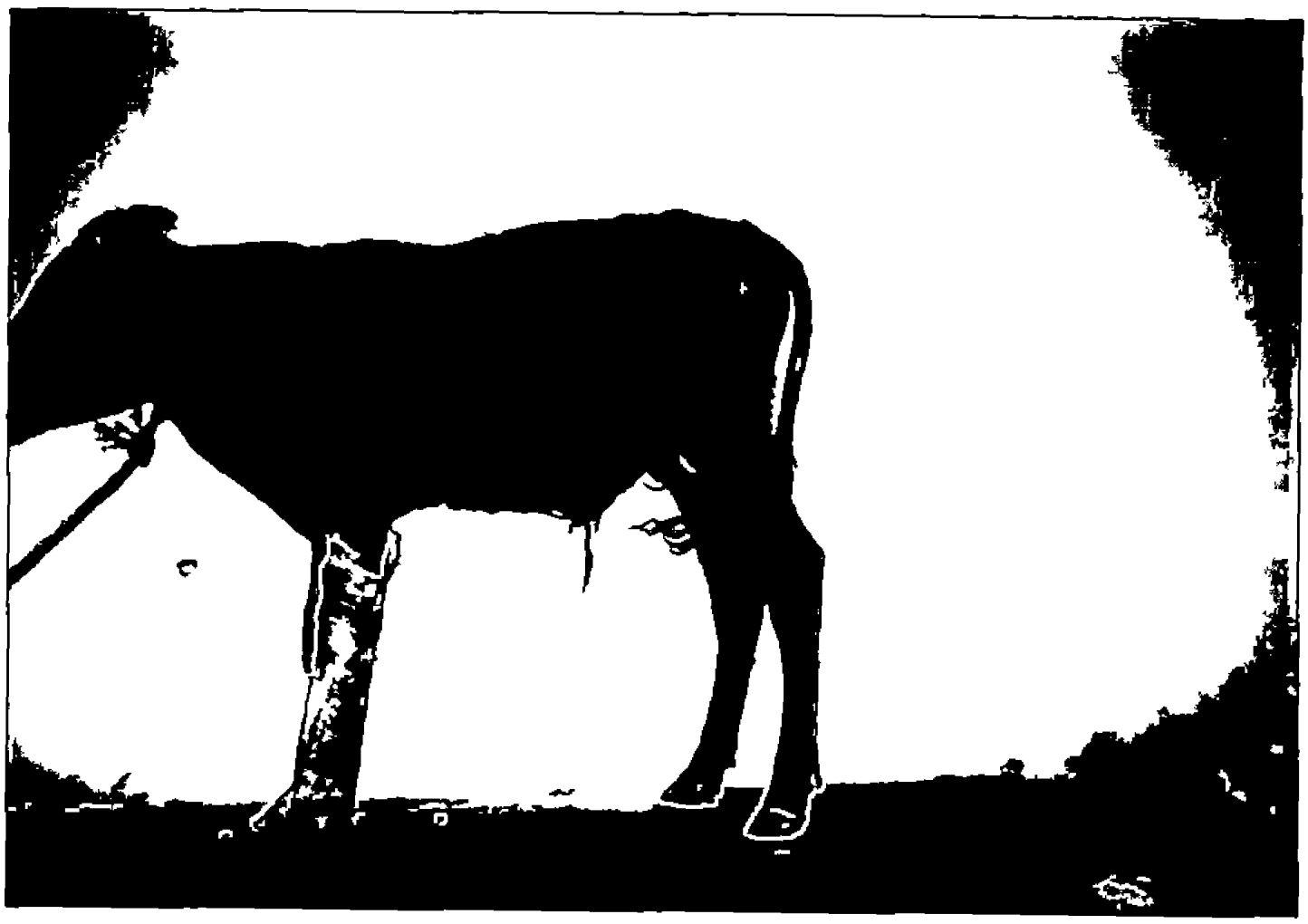
* Bistrepen Alembic Baroda

Fig 7 Immobilisation with gum bandage two weeks after application - Lateral view

Fig 8 Immobilisation with gum bandage - two weeks after application anterior view




PAT

C whenever necessary to ward off flies Radiographs were taken immediately after the surgery and at weekly intervals

The following observations were recorded

1 Clinical symptoms efficacy of immobilisation functional status of the limbs and immobilising dressing

2 Radiographic evaluation of the progress of healing at weekly intervals

3 Macroscopic study of the bone and histological study of the callus

Histological technique

a Fixing and decalcification

Pieces of bone were cut in sizes of 5 mm from the fracture site/callus and were preserved in 10 per cent formol saline The pieces were then decalcified in 10 per cent EDTA solution (Drury et al 1967) Completion of decalcification was confirmed by radiography

b Dehydration and clearing

The tissue that was decalcified was dehydrated by serial passage through 70 per cent 90 per cent and absolute alcohol It was then kept in xylene for 10 minutes and in cedar wood oil until the specimen became transparent

c Paraffin embedding

The specimen from cedar wood oil was passed through xylene then through four changes of melted paraffin wax and was embedded in paraffin

d Section cutting and mounting

A rotary microtome was used for taking sections of 5 - 10μ and the sections were mounted

e Staining

The sections were stained using Haematoxylin and Eosin stain (Drury et al 1967) and Schmorl s Thionin method (Schmorl 1934)

RESULTS

GROUP A

Animal No A 1

The animal was kept under observation for two weeks

Clinical symptoms

First week

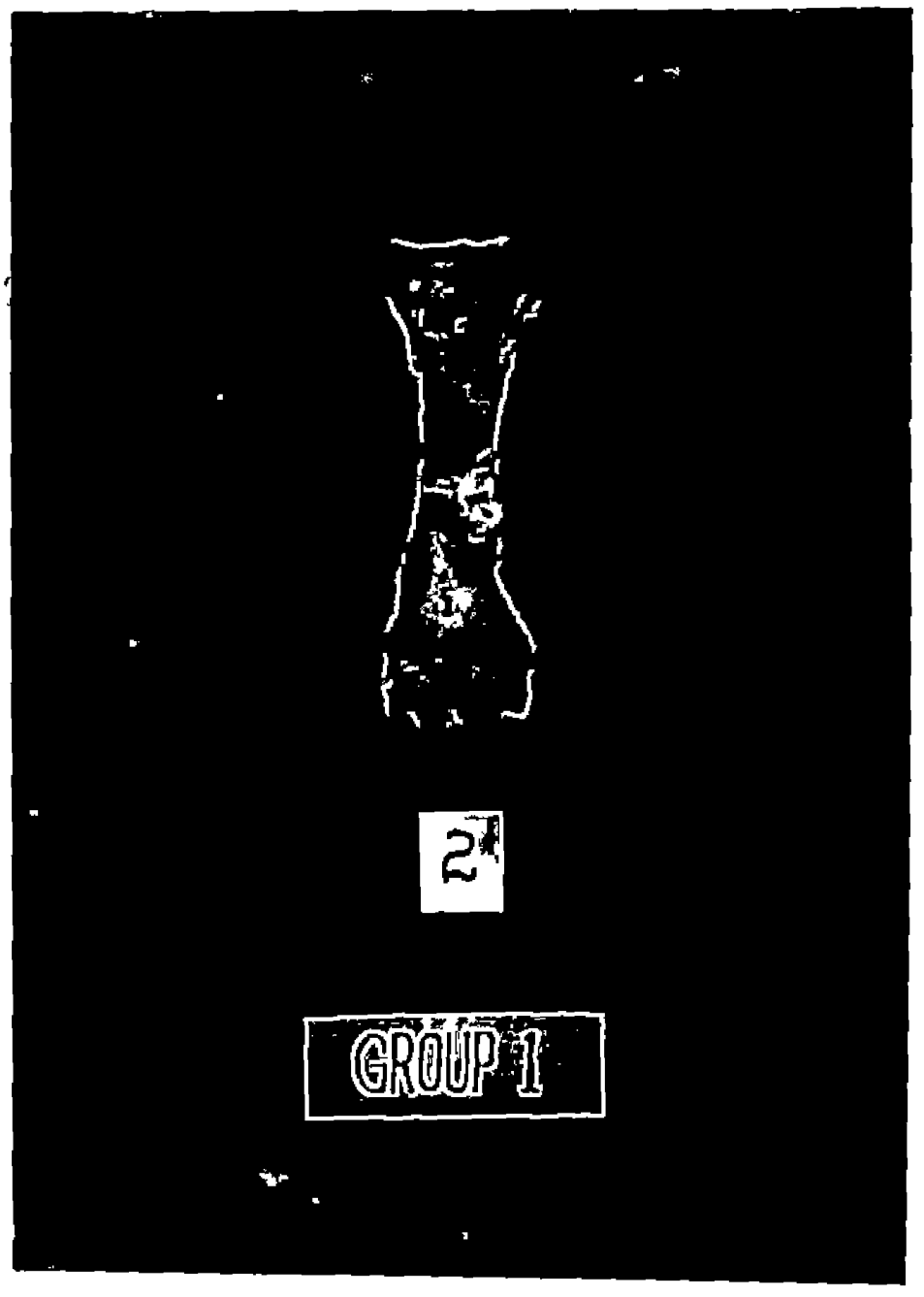
The animal was bearing weight on all the limbs though it favoured the fractured limb and dragged the toes while walking The animal was able to get up and lie down by itself There was oedema at the pastern and the cast was cut longitudinally at its distal end to relieve pressure The animal was bearing weight on the medial digit of the limb

Second week

The cast was removed on the 14th day The skin wound had healed The animal was sacrificed on the 14th day and the bone was cropped The fragments were not united and there was abnormal mobility at the site of fracture (Fig 10)

Fig 9 - Immobilisation with gum bandage - six weeks after application

Fig 10 Bone cropped two weeks after immobilisation with plaster of Paris cast The fragments are separate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GROUP 1

Fig 11 - Radiograph of the large metacarpal bone immediately after immobilisation with plaster of Paris cast

Fig 12 Radiograph of the metacarpal region one week after immobilisation with plaster of Paris cast showing radiodense area close to the site of fracture

Plaster cast

The plaster cast was intact throughout the period of observation

Radiographic observations

After operation

There was proper alignment of the fragments (Fig 11)

First week

The proximal and distal fragments showed radiodense areas close to the site of the fracture (Fig 12)

Second week

The fragments were in apposition and extensive radiodense zones were observed close to the site of fracture (Fig 13)

Histological observations

The cortical bone at the fracture site revealed bone necrosis characterised by empty lacunae Proliferation and thickening of periosteum was observed in the immediate vicinity of fracture Proliferation of capillaries was also noticed at the site (Fig 14)

Fig 17 Radiograph of metacarpal region four weeks after immobilisation with plaster of Paris cast showing well developed callus (a) with ossification close to the fracture site and partially obliterated fracture line

Fig 18 - Photomicrograph of the callus at four weeks showing ossified callus with trabeculae attached to the cortical bone (a)
H & E staining x 60

KSU 32

Clinical symptoms

First week

The animal favoured the limb and was bearing weight on the fractured limb The animal showed pain when pressure was applied below the cast The animal was able to get up and lie down unassisted

Second week

The animal favoured the limb It could get up and lie down unassisted

Third week

The cast was removed because of the exposure of the limb due to a break in the cast A stitch abcess was noticed over the suture line and the skin sutures were removed Cleaned the area and dressed with boric acid powder and a fresh cast was applied

Fourth week

The animal favoured the fractured limb It could get up only when assisted because of general weakness

Fifth week

The animal showed signs of pain when the limb was manipulated The animal was not bearing weight on the fractured limb

Sixth week

The animal had difficulty in getting up There was wasting of the muscles of the limb but the animal was bearing weight on the limb On the 42nd day the animal was sacrificed The callus was palpable and large On cropping the bone fragments were found to be united (Fig 19 20 21 and 22)

Plaster cast

The plaster cast was found broken and hence removed during the third week and a fresh cast was applied This remained intact throughout the period of observation

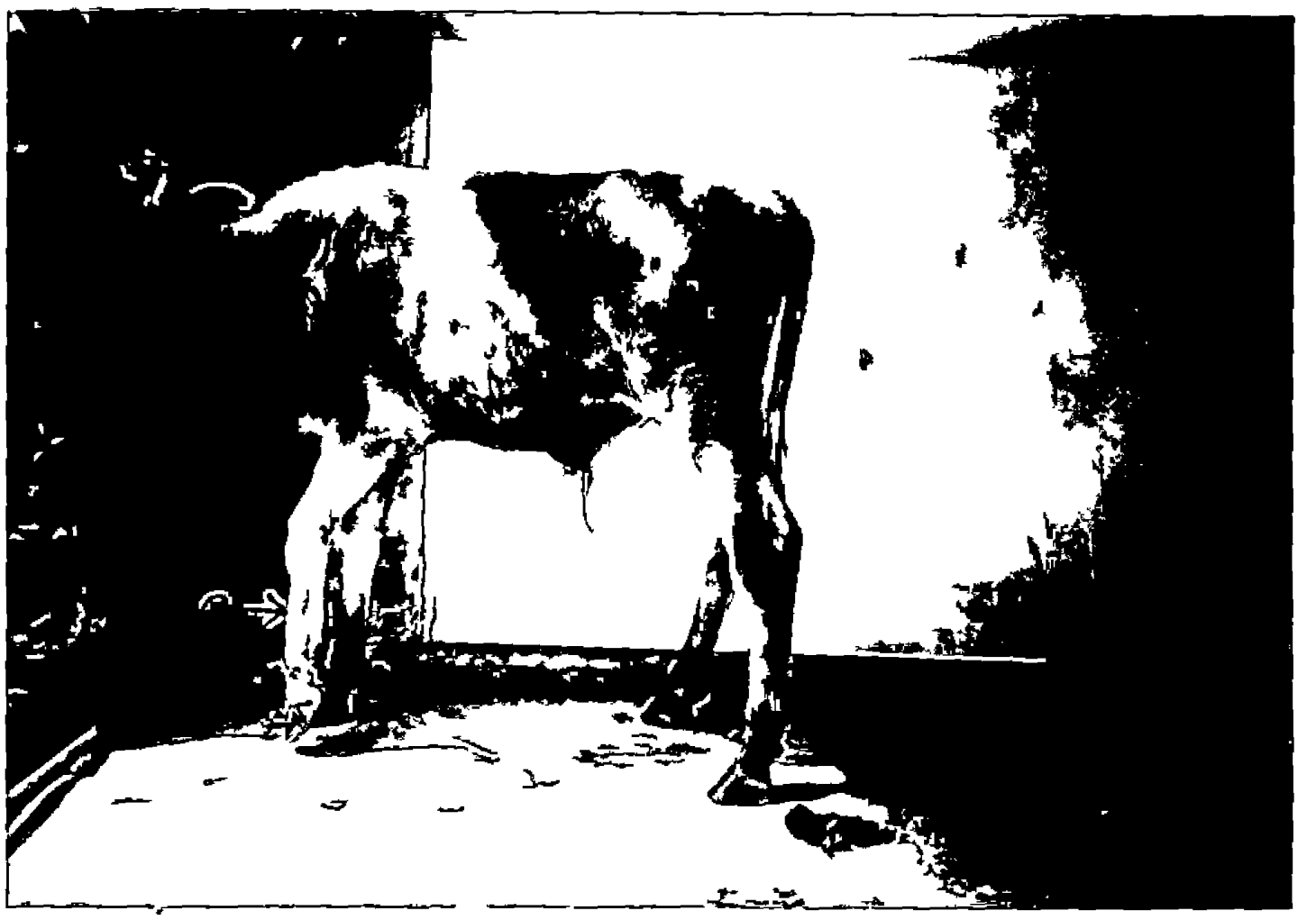
Radiographic observations

After operation

The fragments were in apposition

Fig 19 - Calf - Six weeks after immobilisation with plaster of Paris cast revealing thickening of the limb at the fracture site due to the callus (a)

Fig 20 - Calf Six weeks after immobilisation with plaster of Paris cast The limb is kept abducted



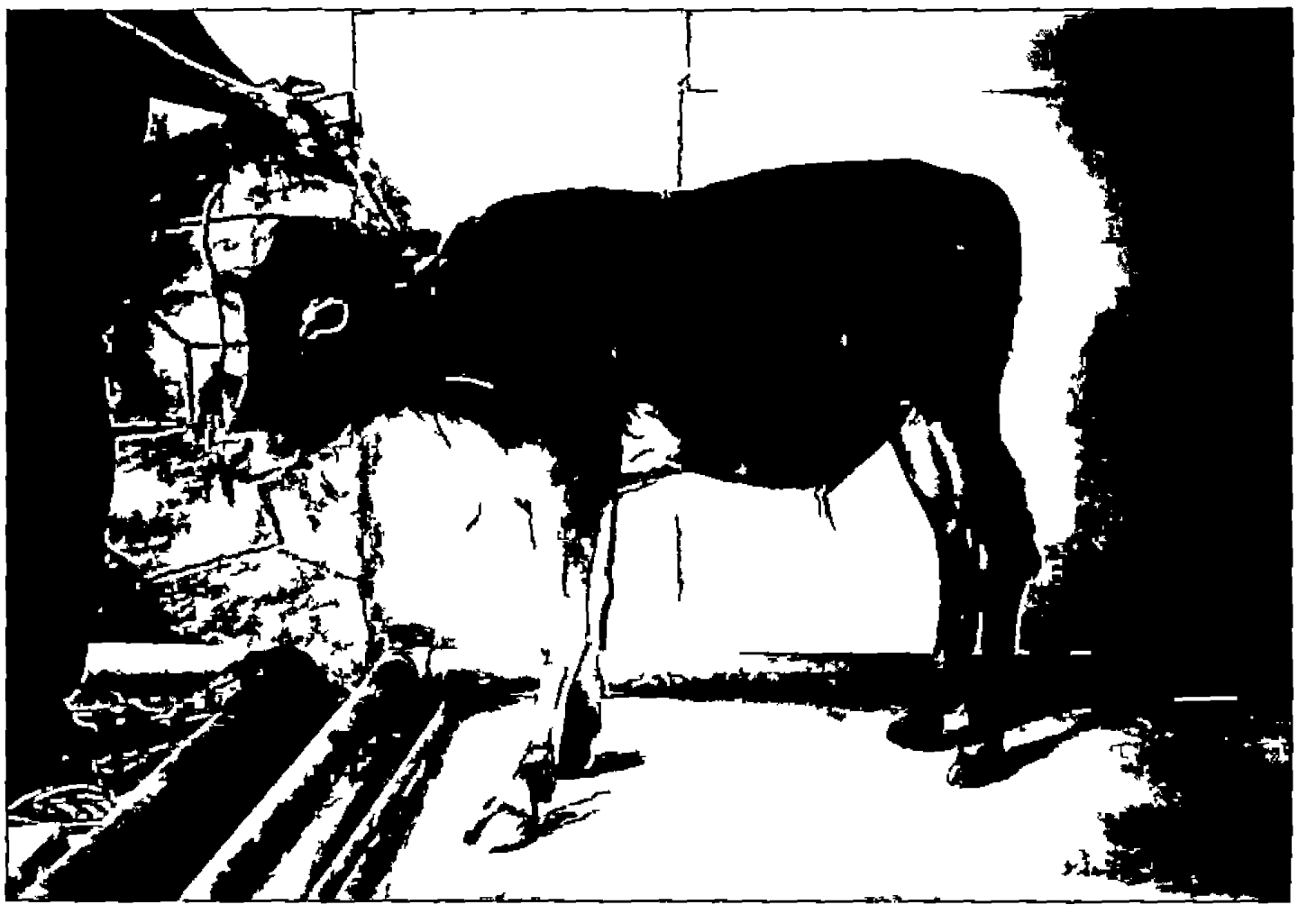
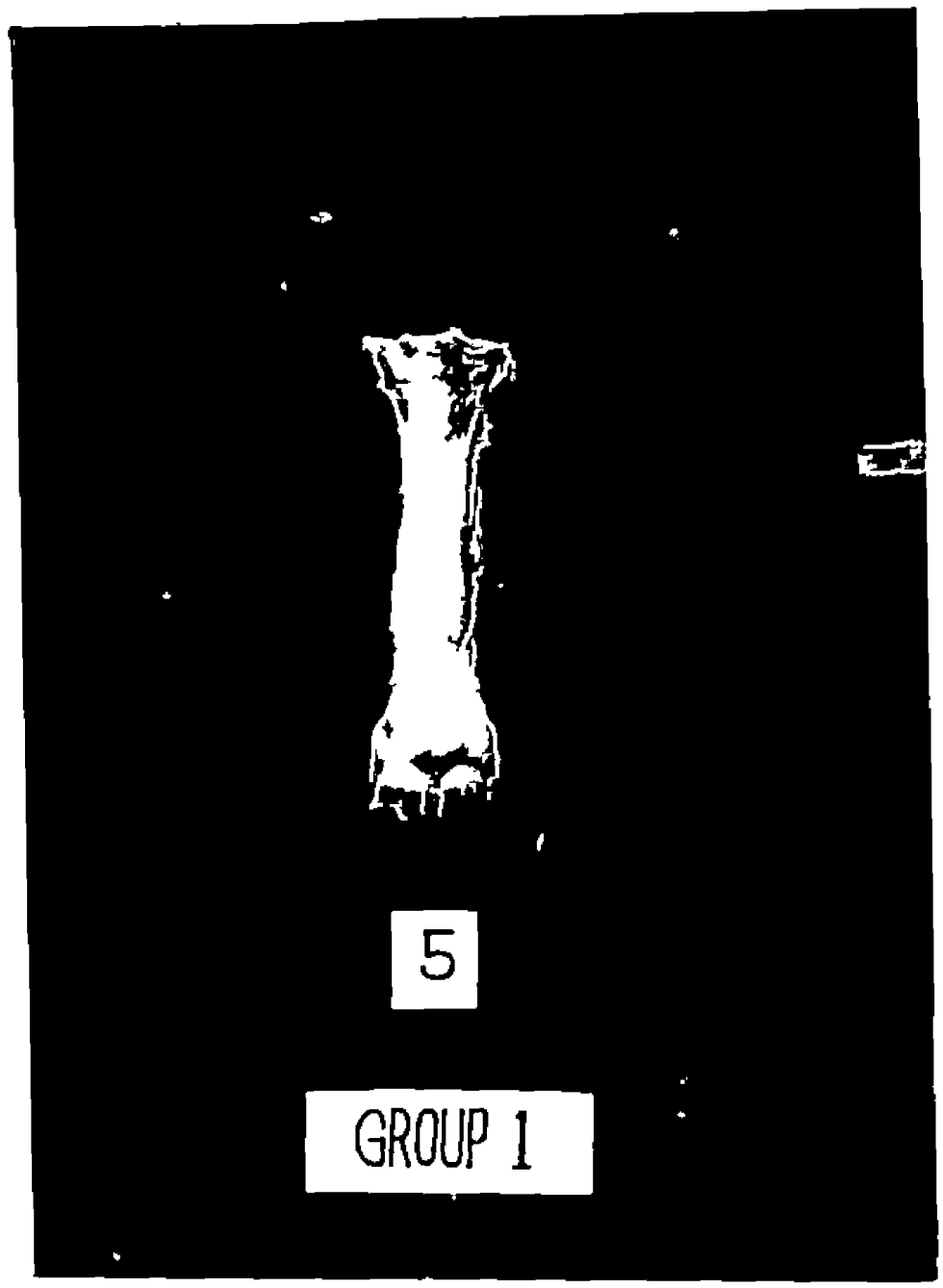


Fig 21 Bone cropped at six weeks after immobilisation with plaster of Paris cast showing well formed callus (a) and union of the fragments

Fig 22 – Bones cropped from animals of Group A (immobilisation with plaster of Paris cast)
1 Four weeks after immobilisation
2 Two weeks after immobilisation
3-6 Six weeks after immobilisation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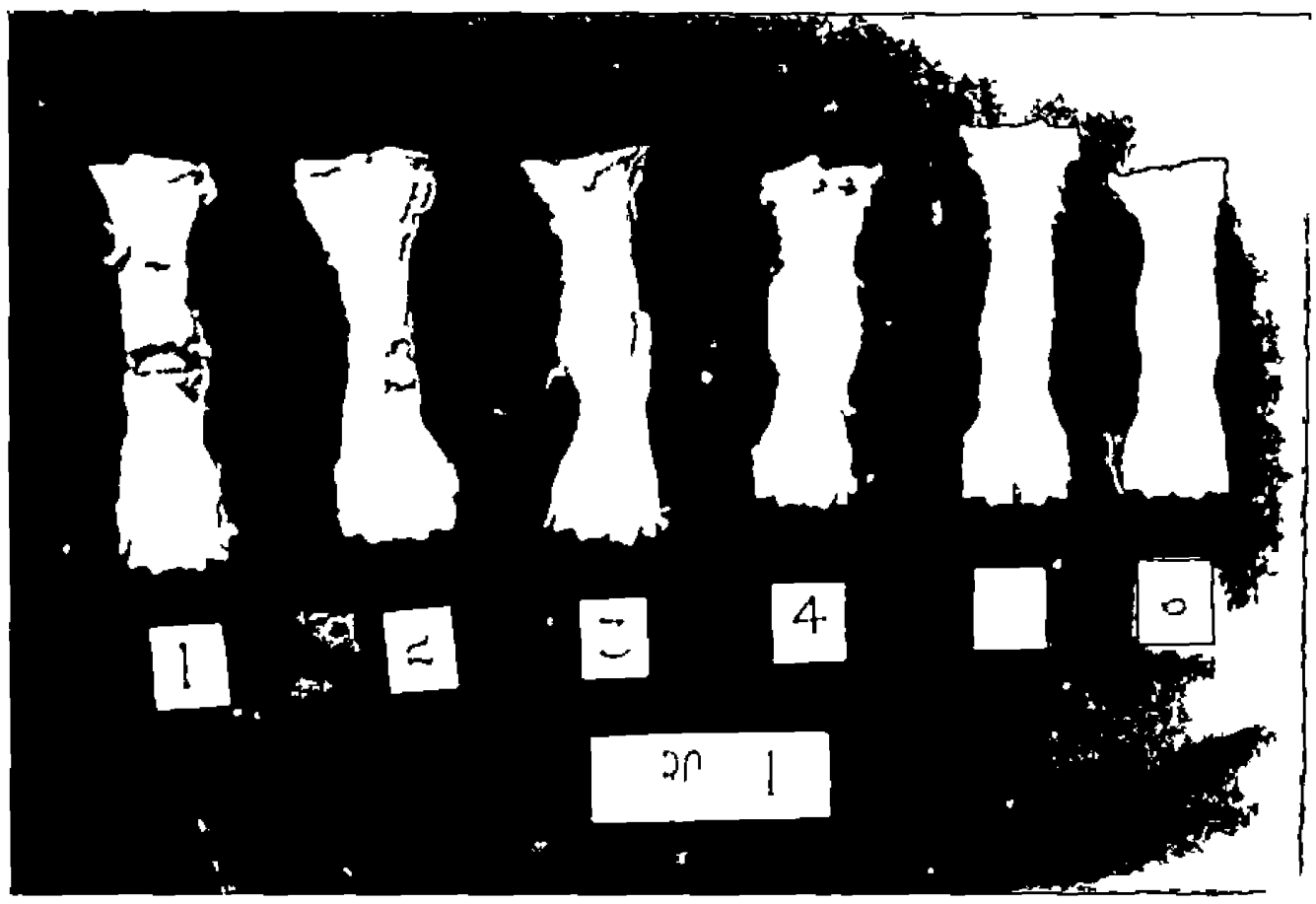
GROUP 1


1
2
3
4
5
GROUP 1

First week

The fragments were in apposition thoug with partial displacement

Second week

The fragments were in apposition though with partial displacement

Third week

Radiodense areas were noticed close to the site of fracture The fracture line had become less distinct due to the radiodense mass The fragments showed partial displacement

Fourth week

Ossification within the radiodense area was apparent The fracture line was less distinct There was a longitudinal split on the proximal fragment of bone near the fracture line

Fifth week

Large areas of ossification were noticed at the fracture site and the fragments showed angulation at the fracture site (Fig 23 and 24)

Sixth week

Ossification of the callus was more extensive and the fragments were connected by the ossified callus There was angulation of the bone at the fracture site The fracture line was partially obliterated (Fig 25 and 26)

Histological observations

The callus had large areas of connective tissue, proliferated blood vessels and zones of hyaline cartilage The ossification of the callus was extensive with formation of trabeculae attached to the cortical bone The trabeculae were continuous within the callus (Figs 27 28 29 30 31 32 and 33)

Animal No A 4

The animal was kept under observation for six weeks

Fig 23 Radiograph of the metacarpal region after five weeks of immobilisation with plaster of Paris cast showing extensive ossification of the callus (a), and partially obliterated fracture line

Fig 24 Radiograph of the metacarpal region after five weeks of immobilisation with plaster of Paris cast revealing displacement and angulation of the fragments extensive ossification at the fracture site (a)

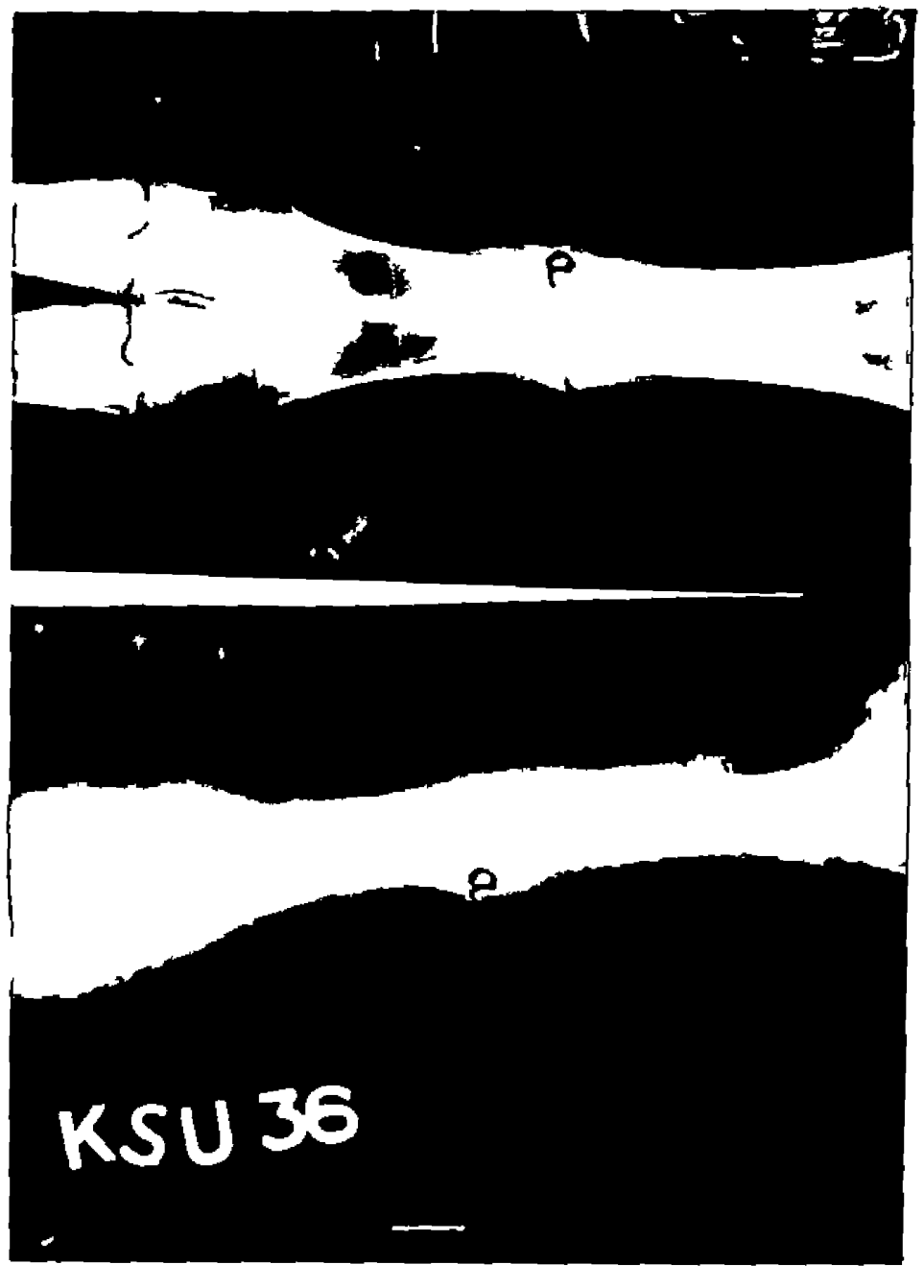
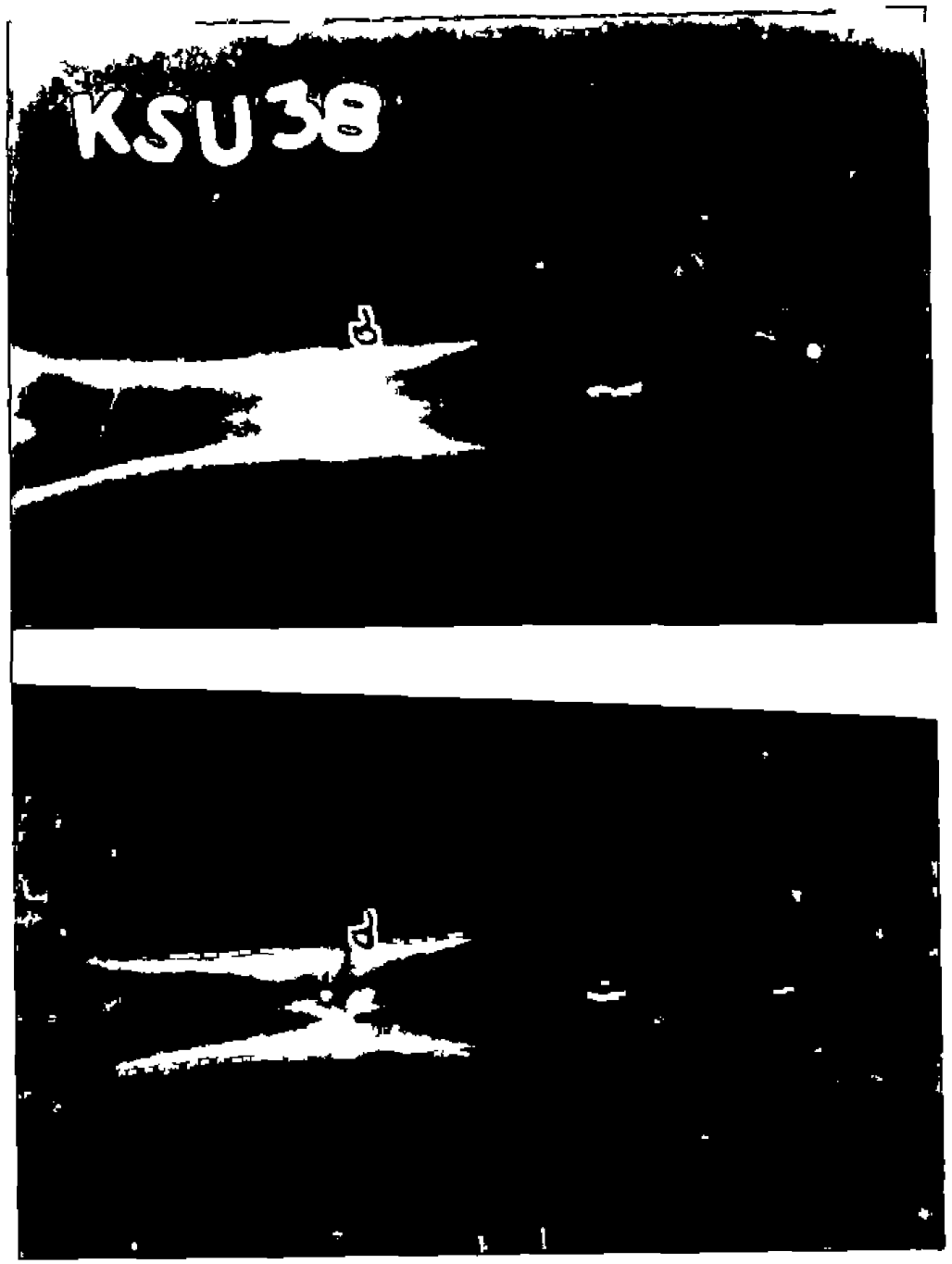
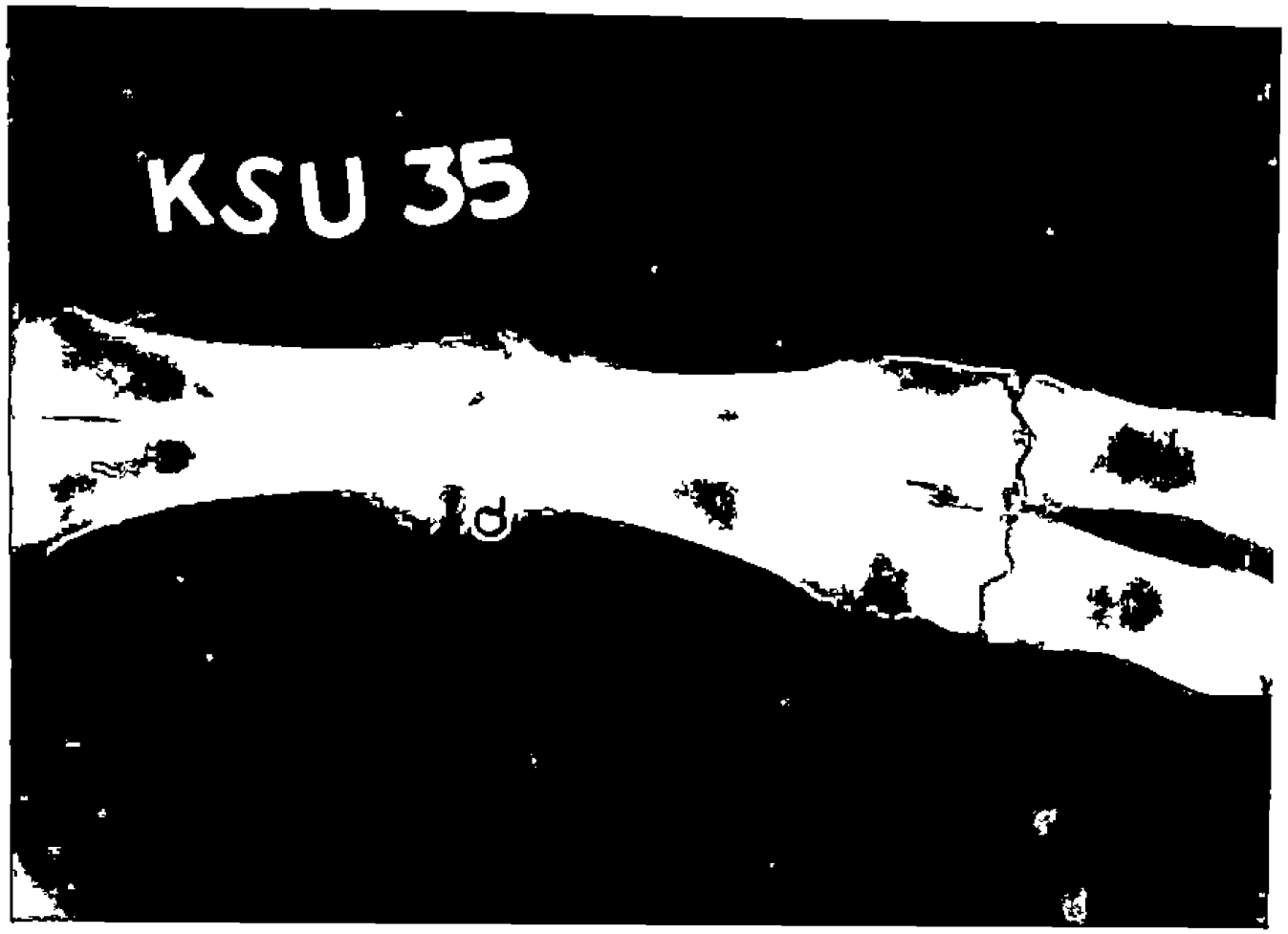

KSU 36

Fig 25 Radiograph of the metacarpal region after six weeks of immobilisation with plaster of Paris cast showing ossification of the callus (a) and partial obliteration of the fracture line

Fig 26 Radiograph of the metacarpal region after six weeks of immobilisation with plaster of Paris cast showing angulation of the fragments ossified callus (a) and partially obliterated fracture line


KSU 38
d
d


KSU 35
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Clinical symptoms

First week

The animal showed difficulty in getting up by the end of the week The cast was loose but intact The animal favoured the limb

Second week

The plaster cast was removed The skin wound had healed The skin sutures were removed and a fresh cast was applied The animal dragged the toes while walking

Third week

Dragging of the toes persisted

Fourth week

The cast was removed Dressed the line of incision with dressing powder before applying a new cast

Fifth week

The animal had difficulty in walking and was weak The animal dragged the toes while walking and had a tendency to stumble

Sixth week

The animal was reluctant to walk and stumbled while walking It was sacrificed on the 42nd day A palpable callus was present The fracture had united and there was no mobility (Fig 22)

Plaster cast

The plaster of Paris cast had become loose and was removed on the eighth day and a fresh cast was applied The cast was broken and was changed on the 22nd day which remained intact till the end of the period of observation

Radiographic observations

After operation

The fragments were in apposition

First week

The fragments were in apposition

Second week

Radiodense area was noticed close to the fragments at the site of the fracture The fracture line was distinct

The ossification of the callus was extensive and characterised by interconnected trabeculae attached to the cortical bone (Figs 27 28 29 30 31 32 and 33)

Animal No A 5

The anima was kept under observation for six weeks

Clinical symptoms

First week

The animal was able to get up and lie down unassisted

Second week

The animal was able to get up and lie down unassisted

Third week

The plaster cast and the skin sutures were removed The suture line was cleaned and was dressed with boric acid powder The wound had healed A fresh plaster cast was applied

Fourth week

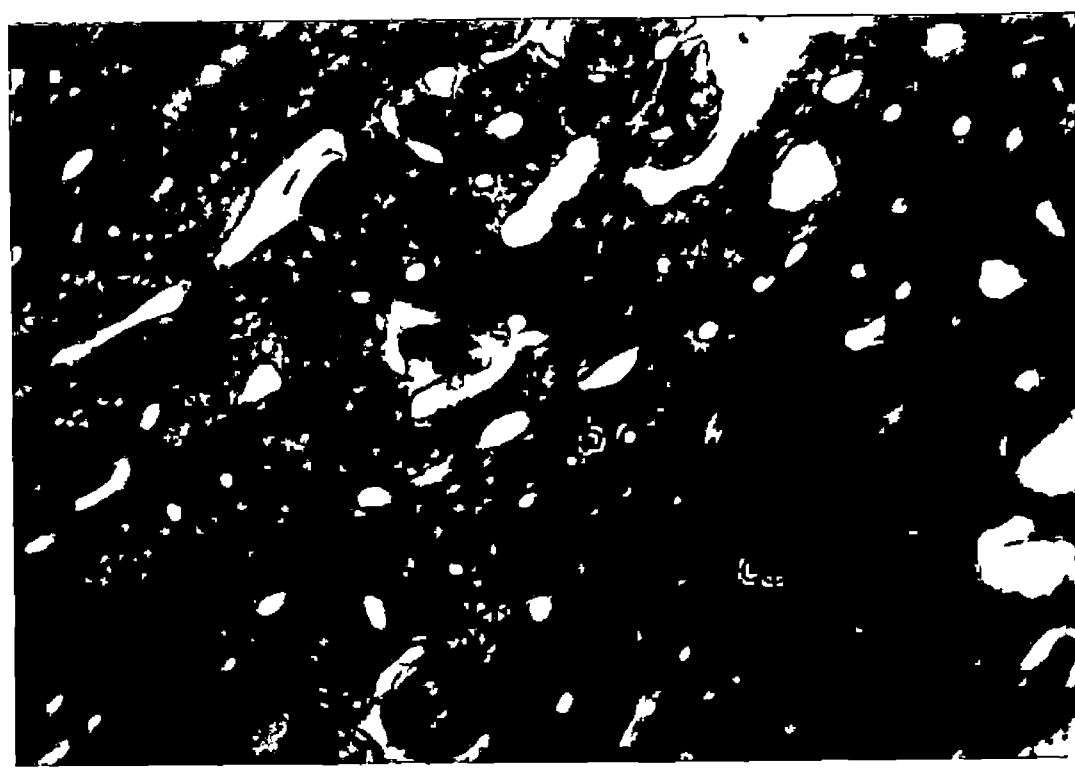
The animal was bearing weight on the limb

Fig 27 - Photomicrograph of the callus six weeks after immobilisation with plaster of Paris cast revealing the fracture line (a) proliferated connective tissue (b) and ossified parts of the callus (c)
H & E staining x 60

Fig 28 Photomicrograph of the callus six weeks after immobilisation with plaster of Paris cast showing proliferated connective tissue (a) trabeculae of new bone (b) attached to the cortical bone
H & E staining x 60

Fig 29 - Photomicrograph of the callus six weeks after immobilisation with plaster of Paris cast showing proliferated connective tissue (a)& interconnected trabeculae (b) of bone
Thionin staining x 60

Fig 30 - Photomicrograph of the callus six weeks after immobilisation with plaster of Paris cast showing the fractured end of the bone (a) with ossified callus on both the sides (b) - (internal and external callus)
Thionin staining x 60



Fifth week

The animal walked without difficulty and was able to bear weight on the limb

Sixth week

The cast became loose and slipped off A fresh cast was applied The animal walked normally bearing weight on the limb but at rest there was pointing of the toes The animal was sacrificed on the 42nd day The bone was cropped The callus was well developed and there was union of the fragments (Fig 22)

Plaster cast

The cast was changed in the third week as it had slipped off The cast became loose and was removed in the sixth week and a fresh cast was applied

Radiographic observations

After operation

The fragments were in apposition

First week

The fragments were in apposition The fracture line was distinct

Second week

The fragments were in apposition

Third week

Radiodense area was noticed around the fragments close to the site of fracture The fracture line was less distinct

Fourth week

Areas of ossification of the callus were noticed adjacent to the site of fracture The fracture line was less distinct

Fifth week

Large areas of ossification with continuity between the ossified zones attached to the proximal and distal fragments was observed

Sixth week

Ossification of the callus was marked and the callus enclosed the two fragments However the fracture line was only partially obliterated

Histological observations

Large areas of connective tissue, proliferating blood vessels and hyaline cartilage were noticed in the callus The ossification of the callus was extensive and characterised by continuous trabeculae of bone attached to the cortical bone (Figs 27 28 29 30 31 32 and 33)

Animal No A 6

The animal was kept under observation for six weeks

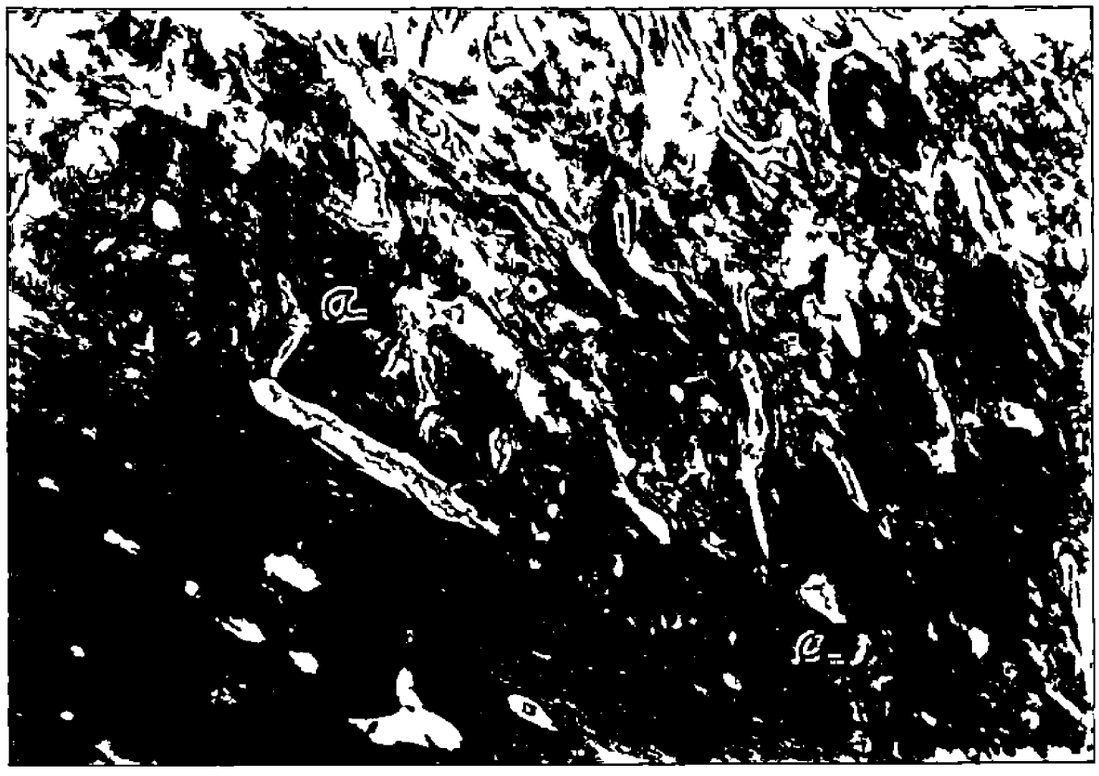
Clinical symptoms

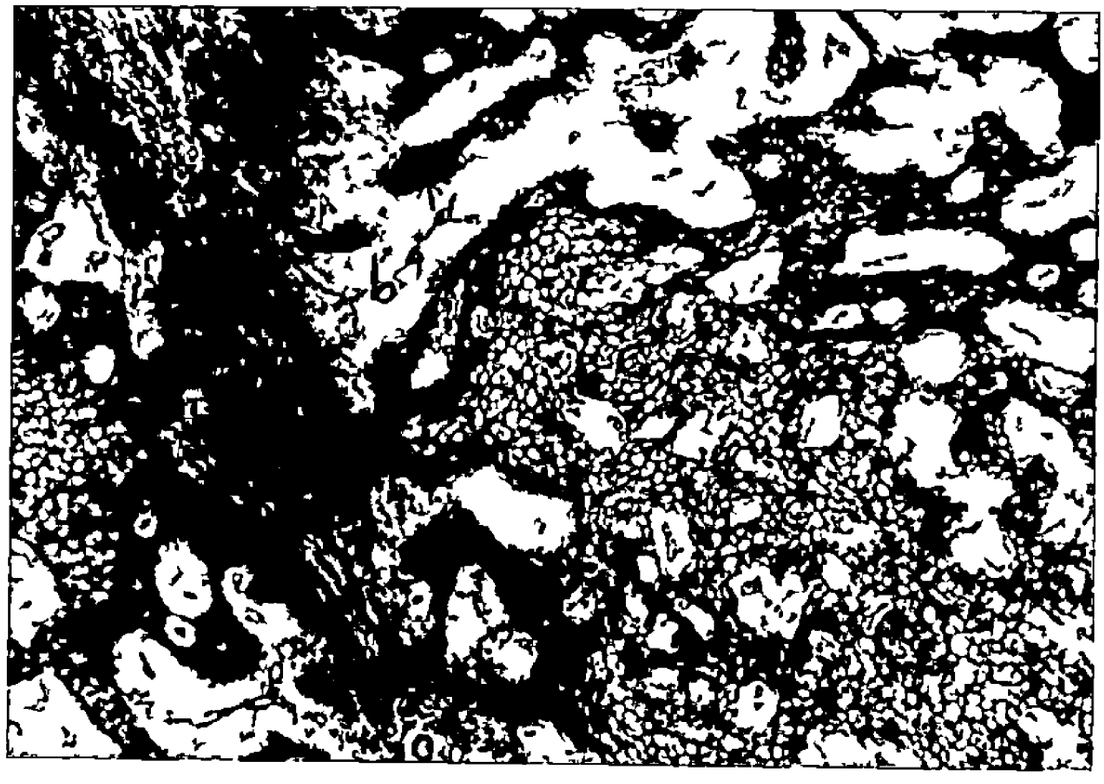
First week

The animal favoured the fractured limb but was getting up unassisted

Fig 31 Photomicrograph of the callus six weeks after immobilisation with plaster of Paris cast showing zones of ossified callus and trabeculae of bone (a) attached to the cortical bone
H & E staining x 60

Fig 32 Photomicrograph of the callus six weeks after immobilisation with plaster of Paris cast showing zones of proliferated blood vessels (a) connective tissue (b) hyaline cartilage (c) and ossification (d)
H & E staining x 60





Second week

The animal favoured the limb but was normal in habits

Third week

The animal was able to get up and lie down unassis ted The animal was able to walk without difficulty

Fourth week

Removed the cast as it became loose The skin wound had healed and the skin sutures were removed The wound was cleaned and dressed with boric acid powder and a fresh cast was applied

Fifth week

The animal was bearing weight on the limb

Sixth week

The animal was walking normally bearing weight on the limb Superficial skin abrasions were observed While standing the animal rested the leg on the toes The

animal was sacrificed on the 42nd day The bone was cropped The callus was well developed and there was union of the fragments (Fig 22)

Plaster cast

The cast was changed during fourth week and the fresh cast remained intact for the period of observation

Radiographic observations

After operation

The fragments were in apposition

First week

The fragments were in apposition though with partial displacement

Second week

Radiodense area was noticed close to the site of fracture

Third week

Areas of ossification were noticed close to the site

of fracture adjoining the proximal and distal fragments There was slight angulation of the fragments at the fracture site

Fourth week

The callus had large areas of ossification and the fracture line was less distinct There was angulation of the fragments at the fracture site

Fifth week

The fracture line was partially obliterated Ossifi cation of the callus was extensive and there was continuity between the ossified callus attached to the fragments

Sixth week

There was angulation of the fragments The ossification of the callus was extensive and the fracture line was almost obliterated

Histological observations

The callus revealed large areas of connective tissue proliferating blood vessels and zones of hyaline

cartilage The ossification of the callus was extensive and characterised by continuous trabeculae of bone attached to the cortical bone (Figs 27 28 29, 30 31 32 and 33)

GROUP B

Animal No B 1

The animal was kept under observation for two weeks

Clinical symptoms

First week

Slight oedema was present at the pastern the next day and the cast was cut longitudinally at the distal end Since the oedema persisted the next day also the cast was further cut longitudinally at its distal end to relieve pressure Abrasions were observed at the region where the cast was tight The animal favoured the limb and was showing signs of pain while walking Since the oedema was persistent the cast was removed The wound was cleaned and dressed with boric acid powder Reapplied the plaster of Paris cast The animal was walking without difficulty though it favoured the limb

Second week

The oedema had subsided The cast was wet and slightly loose The animal could get up and lie down unaided The animal was sacrificed on the 14th day A

blood clot was noticed between the fragments and the fragments were in apposition with restricted mobility (Fig 34)

Transfixation pins and plaster cast

The cast was hard and firm but was changed at the end of the first week due to persistent oedema The second cast became slightly loose when the oedema subsided but remained hard firm and in place for the period of observation

Radiographic observations

After operation

The fragments were in position (Fig 35)

First week

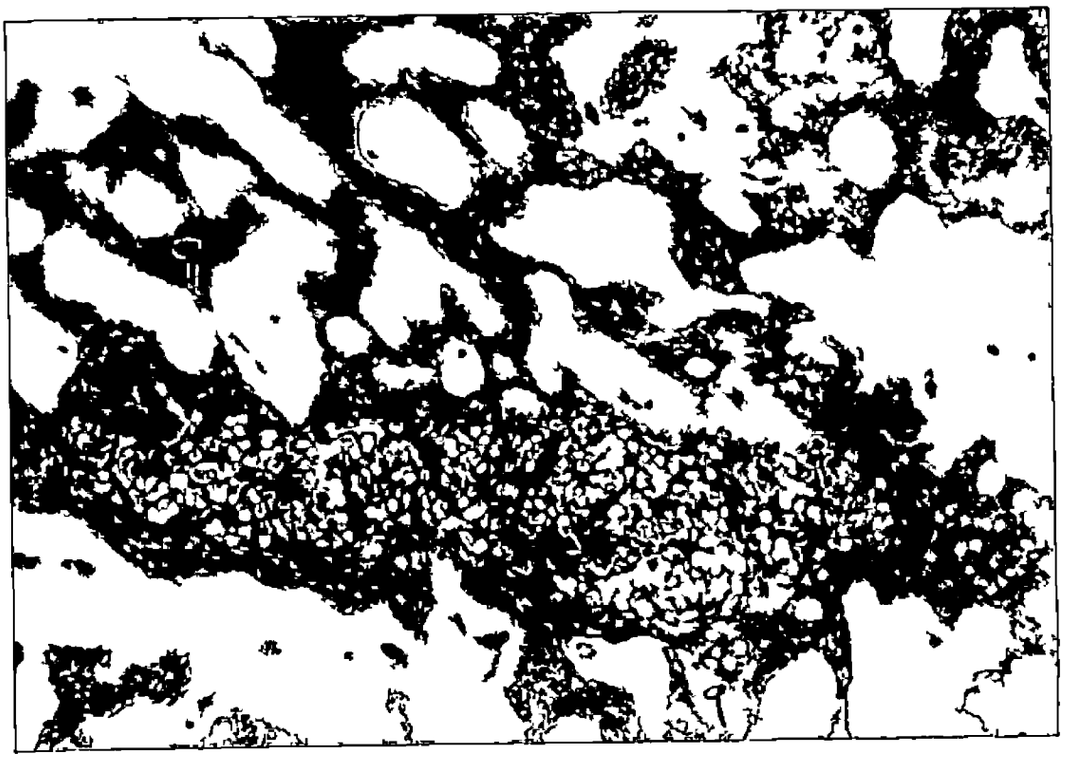
The fragments were in position but with partial displacement (Fig 36)

Second week

The fragments were in position but with partial displacement (Fig 37)

Fig 33 - Photomicrograph of the callus six weeks after immobilisation with plaster of Paris cast showing zone of hyaline cartilage (a) surrounded by trabeculae of new bone (b) Thionin staining x 60

Fig 34 Bone cropped two weeks after transfixation pinning showing the fracture line and partial displacement of the fragments



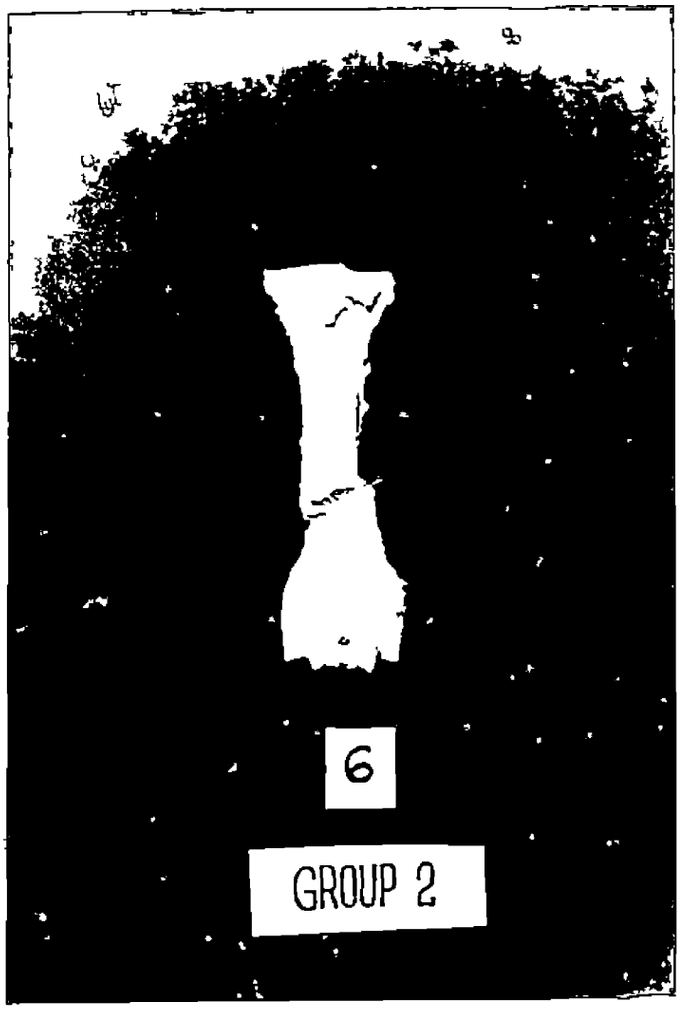

6
GROUP 2

Fig 35 - Radiograph of the metacarpal region immediately after immobilisation with transfixation pin and plaster of Paris cast

Fig 36 Radiograph of the metacarpal region one week after transfixation pinning showing partial displacement of the fragments

Histological observations

Proliferation of the periosteum and connective tissue was noticed close to the fracture site New bone formation was evident adjacent to the cortical bone near the fracture site (Fig 38 and 39)

Animal No B 2

The animal was kept under observation for four weeks

Clinical symptoms

First week

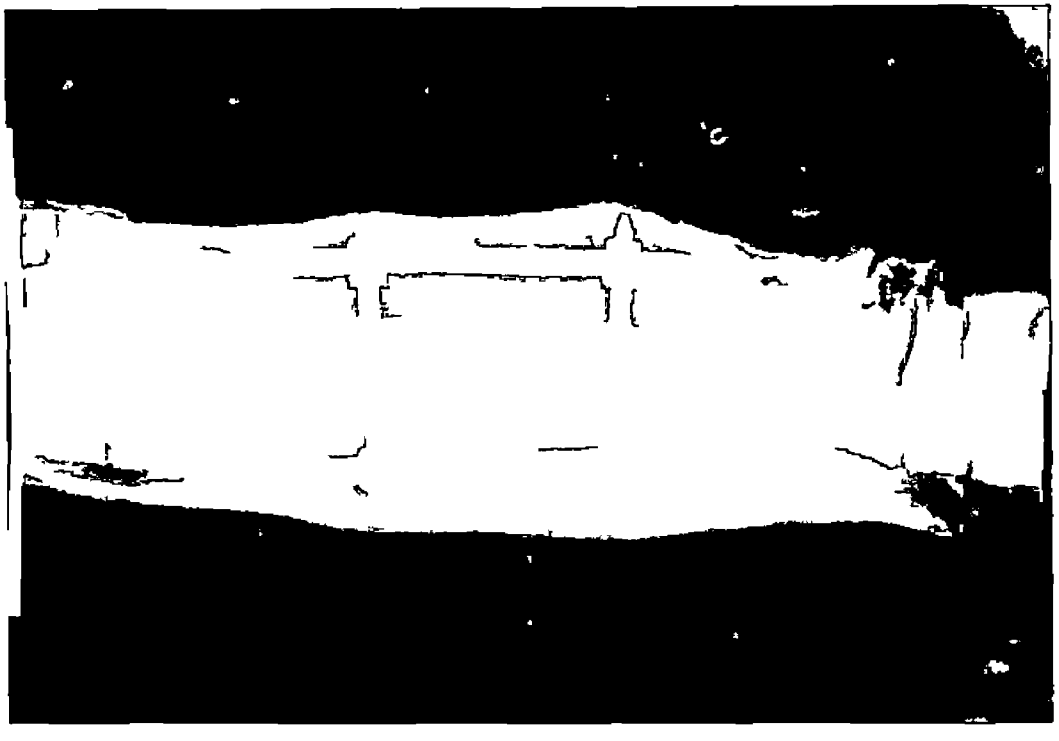
Slight oedema was present at the pastern The cast was cut longitudinally at its distal end to relieve pressure The animal favoured the limb It was able to get up and lie down unaided

Second week

The animal was able to get up and lie down unassis ted Oedema was noticed at the pastern and at the knee A wound was noticed above the fetlock The cast was

Fig 37 Radiograph of the metacarpal region two weeks after transfixation pinning showing partial displacement of the fragments

Fig 38 - Photomicrograph of the callus at two weeks after transfixation pinning showing proliferated connective tissue (a) and zones of ossification close to and continuous with the cortical bone (b)
Thionin staining x 60



removed on the 13th day Serous fluid was seen oozing from the sutured wound The sutures were removed The nuts and plates were removed and the wounds were cleaned Refixed the plates and applied a light plaster cast The animal was not bearing weight on the limb

Third week

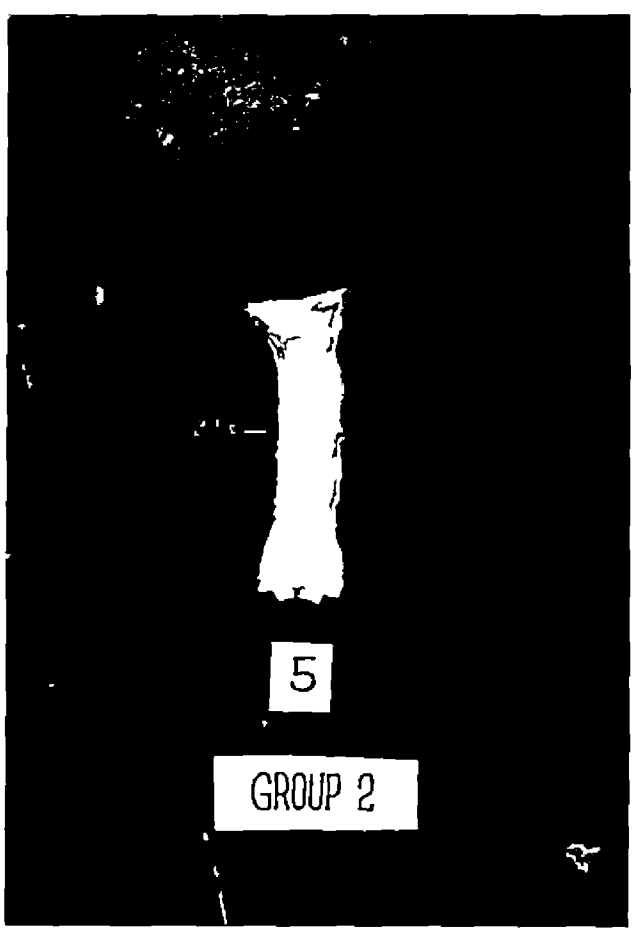
The animal was not bearing weight on the limb The oedema had subsided The cast had become loose and was removed A small quantity of pus was noticed oozing out from a wound at the suture line The wound was cleaned and dressed with boric acid powder A fresh plaster cast was applied

Fourth week

The animal favoured the limb and was not bearing weight on the limb The animal was sacrificed on the 28th day On removing the cast a small quantity of thick offensive smelling pus was noticed at the surgical wound The bone was cropped The fragments were in alignment callus was well developed but soft and there was restricted mobility (Fig 40)

Fig 39 Photomicrograph of the callus at two weeks after transfixation pinning showing proliferated connective tissue (a) and zones of ossification close to and continuous with the cortical bone (b)
H & E staining x 60

Fig 40 Bone cropped four weeks after transfixation pinning showing the soft callus (a)


5
GROUP 2

Transfixation pins and plaster cast

In the second week the plaster cast was changed and a light cast was applied In the third week the plaster cast was damaged and hence removed and a fresh plaster cast was applied after dressing the wound

Radiographic observations

After operation

The fragments were in position

First week

The fragments were in position

Second week

The fragments were in position

Third week

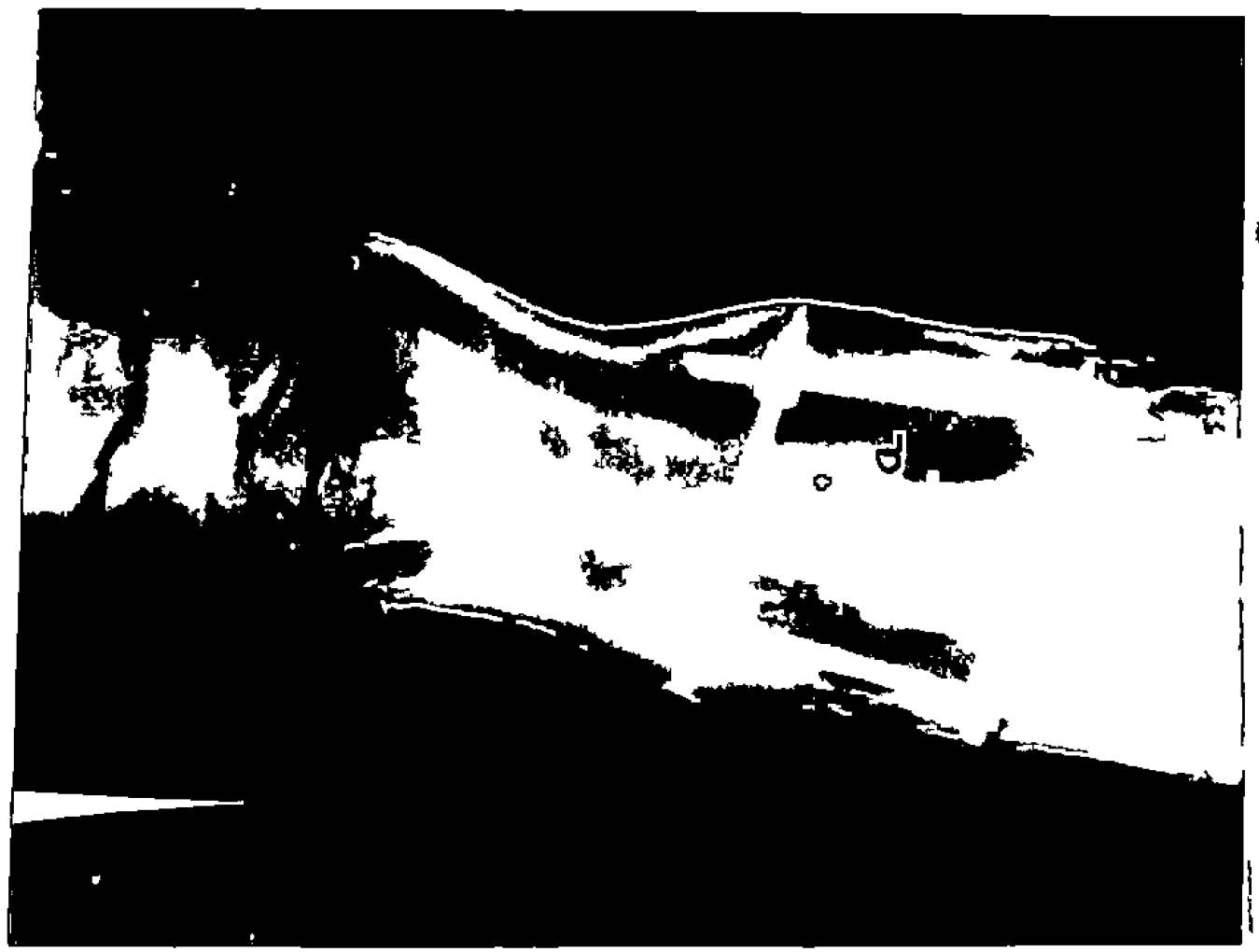
Radiodense areas with zones of ossification were observed at the site of fracture Ossification was observed close to the fragments (Fig 41)

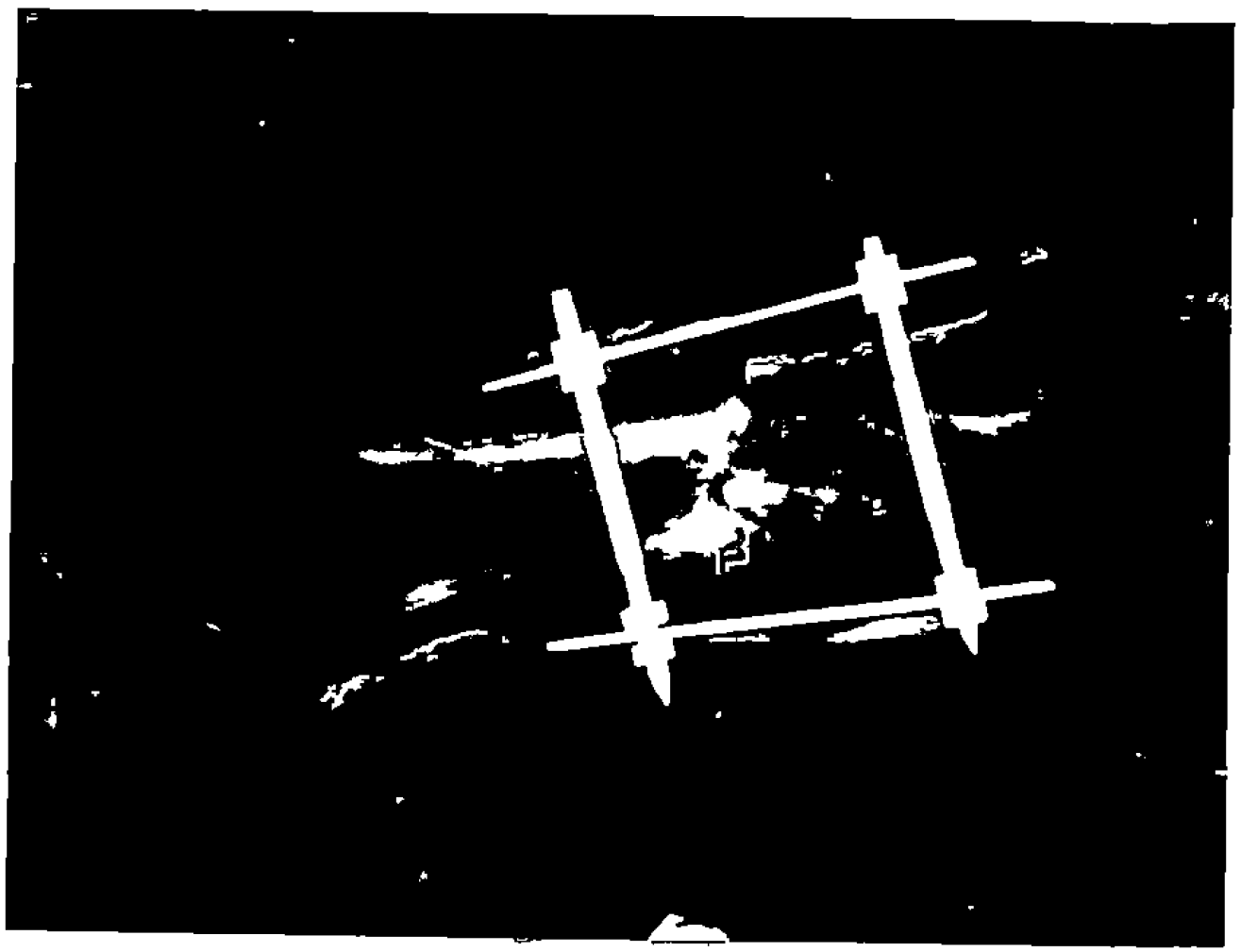
Fourth week

Marked ossification was noticed close to the frag ments (Fig 42)

Fig 41 - Radiograph of the metacarpal region three weeks after transfixation pinning showing ossified callus (a) at the fracture site and partial displacement of the fragments

Fig 42 - Radiograph of the metacarpal region four weeks after transfixation pinning showing partial displacement of the fragments ossified callus (a) and distinct fracture line





Histological observations

The callus revealed centres of inflammation characterised by cellular infiltration and large number of blood vessels and proliferating connective tissue Zones of ossification with formation of trabeculae were noticed in the callus The callus showed zones of extensive ossification resembling cancellous bone (Figs 43 44 and 45)

Animal No B 3

The animal was kept under observation for six weeks

Clinical symptoms

First week

The animal could get up without assistance

Second week

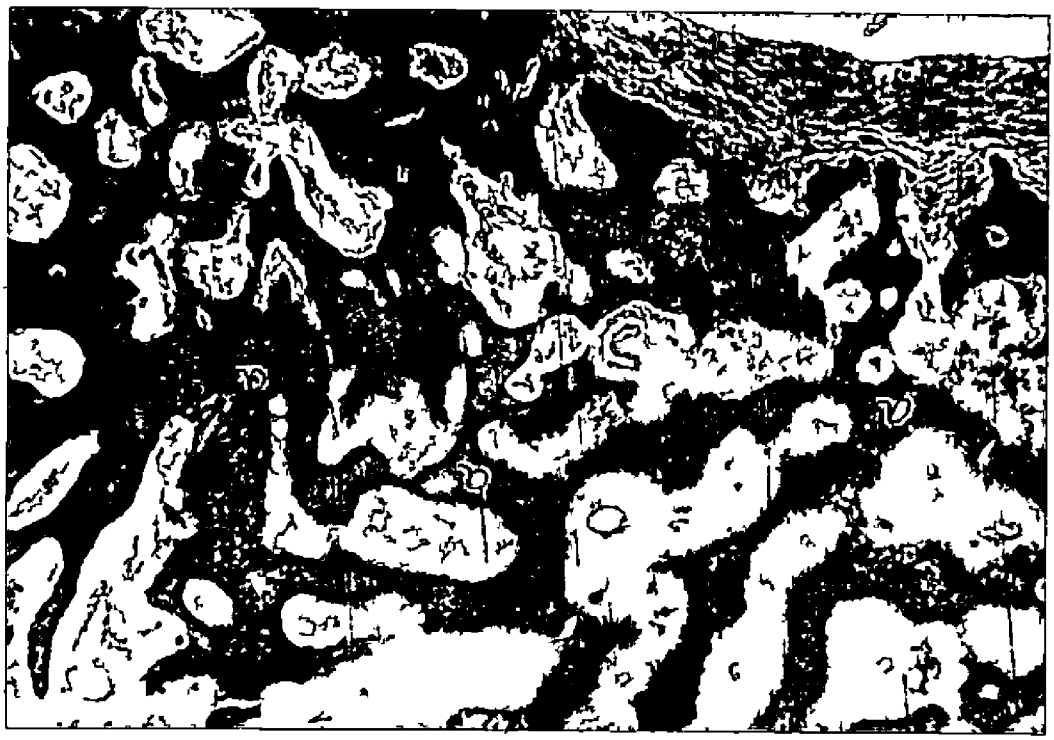
The animal could walk without signs of pain but it favoured the fractured limb

Third week

The animal was bearing weight on the limb

Fig 43 Photomicrograph of the callus four weeks after transfixation pinning showing ossified callus with formation of trabeculae (a) and proliferated connective tissue (b) H & E staining x 60

Fig 44 - Photomicrograph of the callus four weeks after transfixation pinning showing zones of ossified callus with trabeculae (a) H & E staining x 60



Fourth week

The animal was walking without difficulty The animal was bearing weight on the fractured limb but it favoured the limb

Fifth week

Towards the end of the week the animal was bearing weight on the fractured limb and was able to use the limb normally

Sixth week

The animal did not show signs of pain on manipulating the fractured limb When the cast was removed the animal could walk and run without difficulty The animal was sacrificed on the 42nd day The bone was cropped The callus was well developed and the fragments had united (Figs 46, 47 and 48)

Transfixation pins and plaster cast

The cast remained intact hard and firm throughout the period of observation

Fig 45 Photomicrograph of the callus four weeks after transfixation pinning showing cellular infiltration (a) proliferated blood vessels (b) and zones of ossification (c) H & E staining x 160

Fig 46 Bone cropped six weeks after transfixation pinning showing continuity of the bone and thickening of the shaft due to the callus(a)

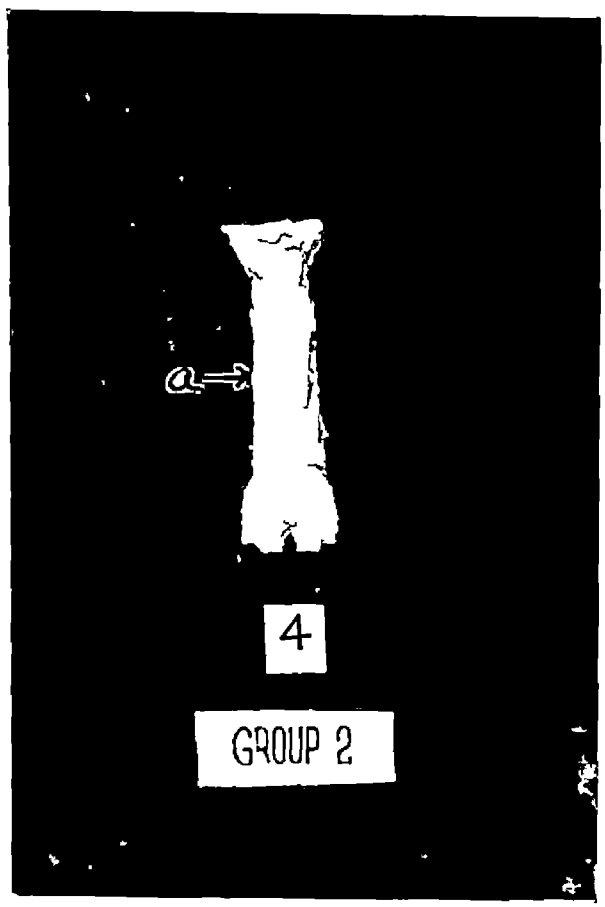

4
GROUP 2

Fig 47 Bones cropped in Group B (Transfixation pinning)

1-4 Six weeks after immobilisation

5 Four weeks after immobilisation

6 - Two weeks after immobilisation

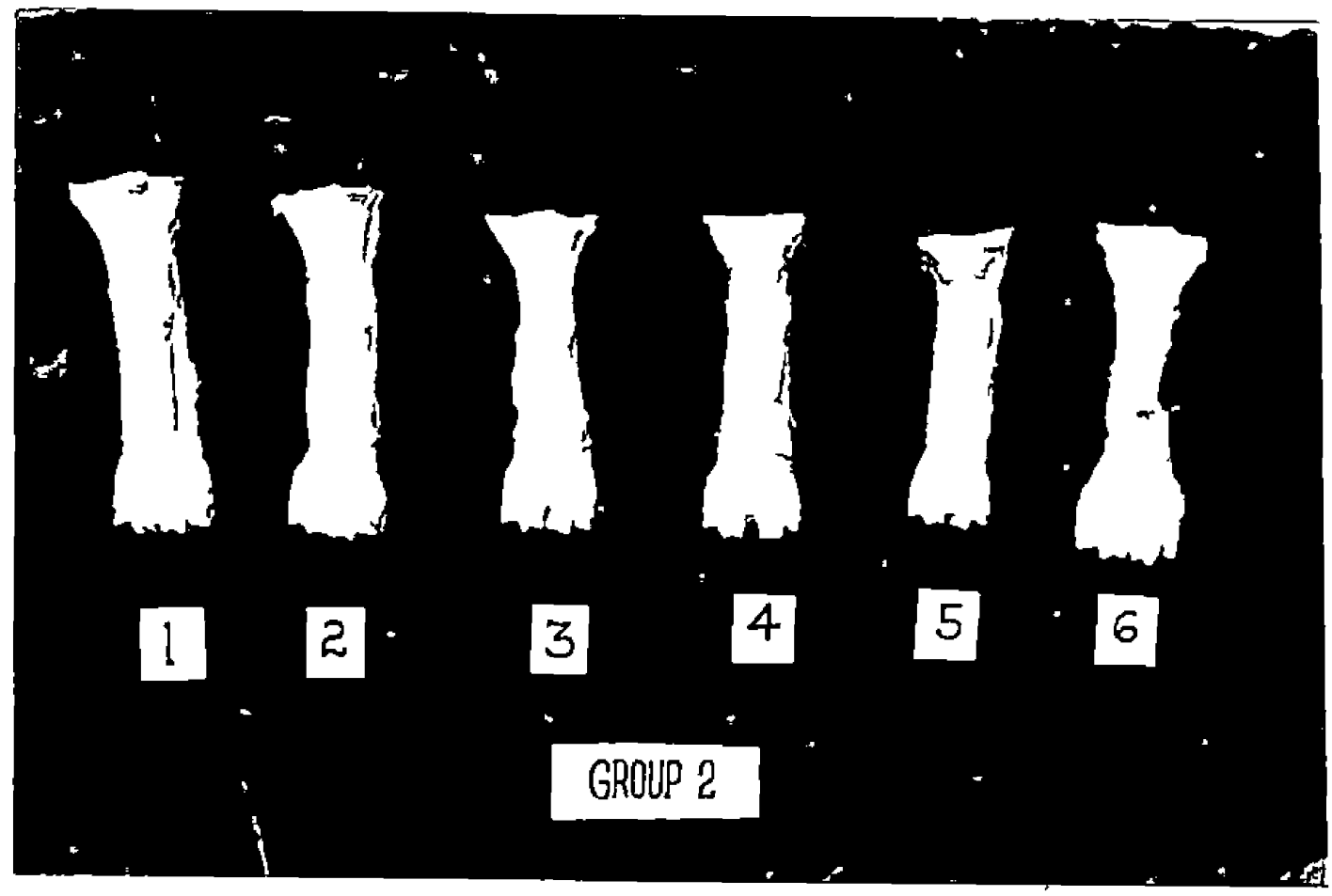
Fig 48 - Lateral view of the bones cropped in Group B (Transfixation pinning)

1 4 Six weeks after immobilisation

5 - Four weeks after immobilisation

6 - Two weeks after immobilisation

The points where the pins have entered are seen (a)


1
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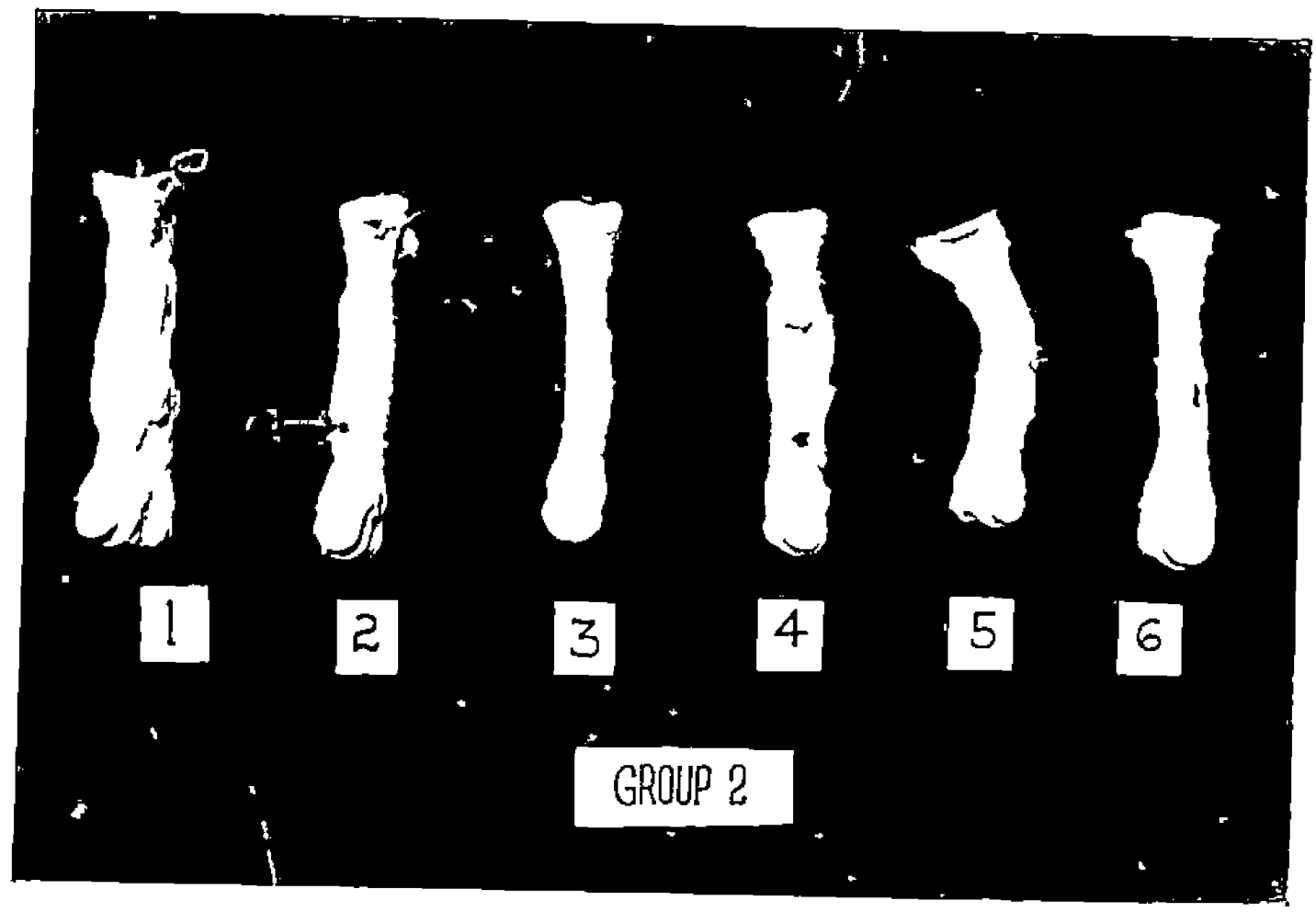
6
GROUP 2


1
2
3
4
5
6
GROUP 2

Radiographic observations

After operation

The fragments were in position

First week

The fragments were in position but with partial displacement of the distal fragment

Second week

Radiodense areas with zones of ossification were noticed at the fracture site

Third week

Marked ossification was observed at the fracture site and the fracture line was less distinct

Fourth week

Ossification of the callus was extensive and continuous with both the fragments The fracture line was less distinct

Fifth week

The callus was well developed with extensive ossification and the ossified callus was continuous between the two fragments The fracture line was partially obliterated (Fig 49)

Sixth week

Ossification of the callus was extensive and the two fragments were united by the callus There was slight angulation of the bone at the fracture site The fracture gap was partially obliterated (Fig 50)

Histological observations

Large areas of ossification with osseous trabeculae arranged similar to cancellous bone were observed Small areas of connective tissue were noticed within the new bone formed Inflammatory changes characterised by cellular infiltration and proliferation of capillaries were present Osseous trabeculae were seen on both the sides of the cortical bone indicating ossification of both the internal and the external callus (Fig 51 52 53 54 55 56 and 57)

Fig 49 - Radiograph of the metacarpal region five weeks after transfixation pinning showing ossification at the fracture site (a) proliferative reaction near the pins (b) and partial obliteration of the fracture line

Fig 50 - Radiograph of the metacarpal region six weeks after transfixation pinning revealing ossified callus (a) osteolytic changes close to the pins (b) and partially obliterated fracture line


a
b

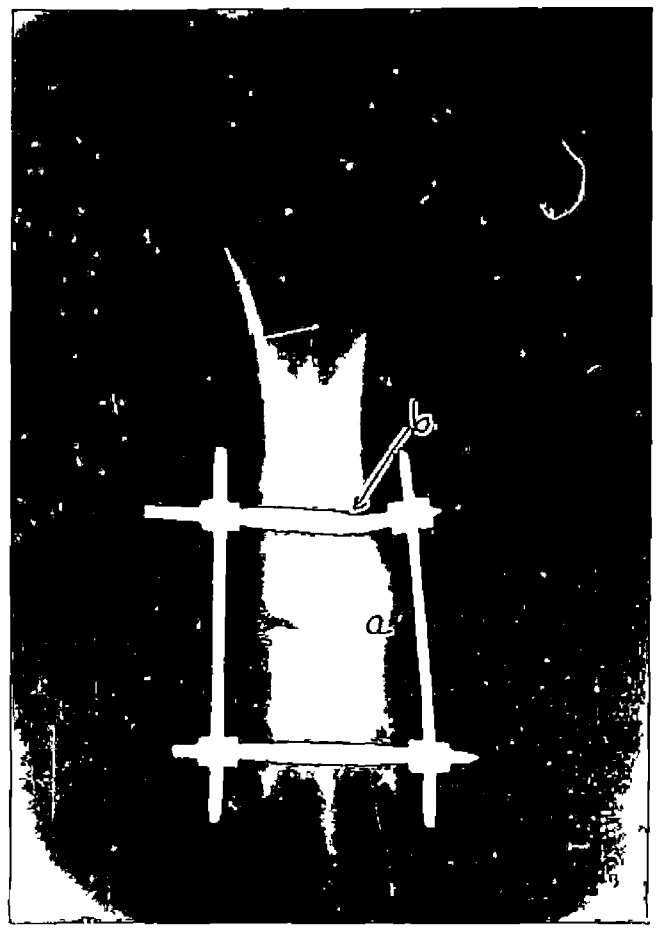

b
a

Fig 51 Photomicrograph of the callus six weeks after transfixation pinning showing ossified callus with trabeculae formation (a) on both the sides of the cortical bone (b) Thionin staining x 60

Fig 52 - Photomicrograph of the callus six weeks after transfixation pinning showing osseous trabeculae of callus (a) arranged similar to cancellous bone and prolife rated connective tissue (b) Thionin staining x 60

Animal No B 4

The animal was kept under observation for six weeks

Clinical symptoms

First week

On the sixth day the cast was removed because it was moist and discoloured with blood The suture line was cleaned with sterile gauze and dressed A fresh cast was applied The animal was bearing weight on the limb

Second week

The animal could lie down, get up and walk without assistance By the end of the week the animal had difficulty in using the limb

Third week

The animal was reluctant to walk Although pronounced limping was noticed, it was bearing weight on the limb The animal favoured the limb

Fourth week

The animal favoured the fractured limb There was lameness

Fifth week

The animal showed signs of lameness on walking though it did not show any sign of pain on manipulation of the limb

Sixth week

While standing, the animal was not bearing weight on the limb, and the knee was kept flexed The animal was able to get up and lie down unaided By the end of the sixth week, the animal started bearing weight on the limb while standing The cast was damaged and was removed The sutures were intact The skin wound had healed The animal was sacrificed on the 42nd day The bone was cropped. The callus was well formed The pins were found to be loose (Fig 47 and 48)

Transfixation pins and plaster cast

During the first week, the plaster cast became damaged and it was removed A fresh cast was applied During the sixth week the cast became damaged but was intact

Radiographic observations

After operation

The fragments were in apposition

First week

The fragments were in apposition

Second week

Radiodense areas with zones of ossification were observed at the site of fracture

Third week

The periosteal reaction was more apparent with large areas of ossification adjacent to the cortical bone

Fourth week

The proximal pin was bent The fracture line was less distinct

Fifth week

The callus showed extensive ossification There was osteolytic reaction in the vicinity of the pin in the

proximal fragment The fracture gap was partially obliterated

Sixth week

Marked ossification of the callus was noticed The fracture gap was mostly obliterated There were osteolytic changes close to the pins

Histological observations

The callus showed large areas of osseous trabeculae arranged similar to cancellous bone and a zone of hyaline cartilage Small areas of connective tissue were noticed within the new bone formed Osseous trabeculae were seen on both the sides of the cortical bone indicating ossification of both the internal and the external callus (Fig 51 52 53 54, 55 56 and 57)

Animal No B 5

The animal was kept under observation for six weeks

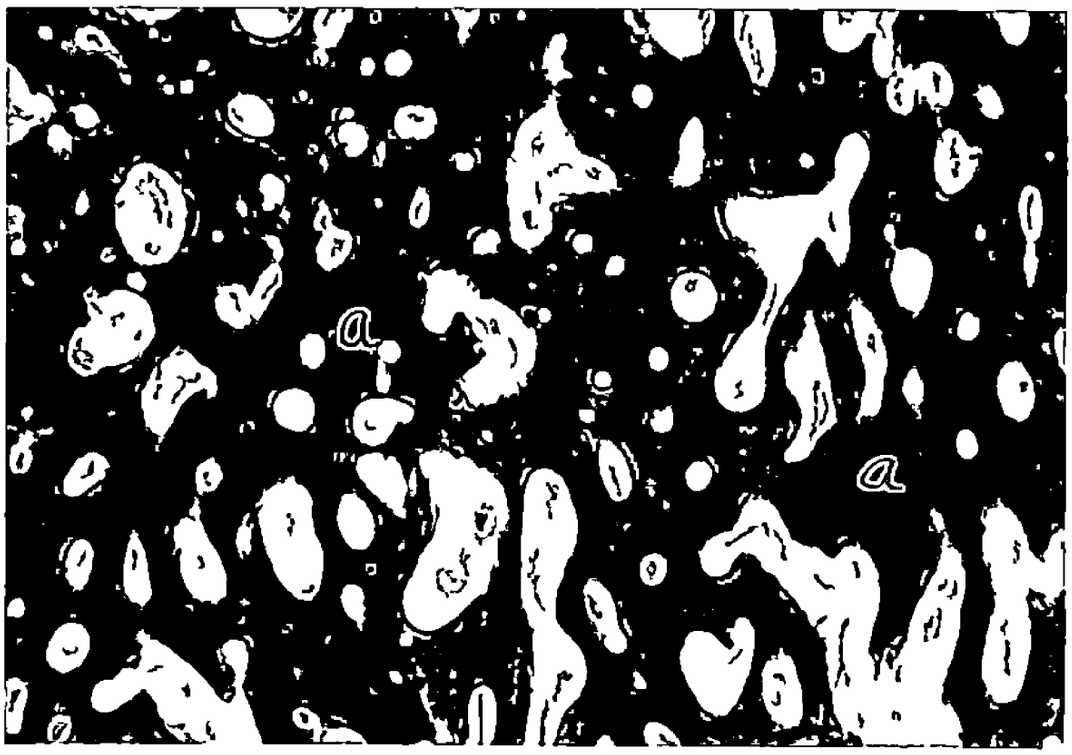
Clinical symptoms

First week

From the second day the animal was standing unaided though it favoured the limb The cast was

Fig 53 Photomicrograph of the callus six weeks after transfixation pinning showing osseous trabeculae of callus (a) arranged similar to cancellous bone
Thionin staining x 60

Fig 54 Photomicrograph of the callus six weeks after transfixation pinning showing newly formed bone at the fracture site (a)
Thionin staining x 160


a
a


a

damaged and was removed on the sixth day The wound was cleaned and dressed with boric acid powder and the cast reapplied

Second week

The animal could get up and lie down unaided The animal favoured the limb but did not show any sign of pain while the limb was manipulated

Third week

Slight oedema was noticed distal and proximal to the cast The cast was cut at the upper and lower ends longitudinally to relieve pressure The animal was lame on the fractured limb

Fourth week

The oedema had subsided At rest the animal was not bearing weight on the fractured limb

Fifth week

The animal walked with pronounced lameness and favoured the limb The cast was removed on the 33rd day because it was damaged There was bleeding from the

suture line The sutures were removed The suture line was cleaned dressed with boric acid powder and applied a fresh plaster cast The animal was bearing weight on the limb while walking

Sixth week

The animal was sacrificed on the 42nd day and the bone was cropped The callus was well formed and there was union of the fracture (Fig 47 and 48)

Transfixation pins and plaster cast

The plaster cast was changed during the first week and during the fifth week

Radiographic observations

After operation

The fragments were in position

First week

The fragments were in position but there was partial displacement of the distal fragment

Second week

The displacement was still persistent Radiodense area was observed at the fracture site with ossification close to the proximal fragment

Third week

Ossification of the callus was noticed close to the proximal and distal fragments at the fracture site

Fourth week

Marked ossification of the callus was apparent close to the proximal and distal fragments Osteolytic changes were noticed in the cortical bone adjacent to the pins

Fifth week

Ossification of the callus was marked close to the proximal and distal fragments Osteolytic reaction was noticed in the cortical bone adjacent to the pins

Sixth week

The callus was ossified connecting the proximal and distal fragments Osteolytic changes were present

adjacent to the pins The fracture line was partially obliterated

Histological observations

Large areas of ossification with the trabeculae arranged similar to cancellous bone was noticed Small areas of connective tissue were noticed within the new bone formed Newly formed osseous trabeculae were seen on both the sides of the cortical bone indicating ossification of both the internal and external callus (Fig 51 52 53 54, 55 56 and 57)

Animal No B 6

The animal was kept under observation for six weeks

Clinical symptoms

First week

The animal favoured the fractured limb The animal could get up and lie down unaided

Fig 55 - Photomicrograph of the callus six weeks after transfixation pinning showing osseous trabeculae (a) and proliferated connective tissue (b)
H & E staining x 60

Fig 56 Photomicrograph of the callus six weeks after transfixation pinning revealing osseous trabeculae (a) and proliferated connective tissue (b)
H & E staining x 60


a
b
a
a


a
a
b
A

Second week

The animal was bearing weight on the limb There was pointing of the toes of the fractured limb at rest

Third week

The animal was bearing weight on the fractured limb while walking There was oedema distal to the plaster cast The cast was removed on the 15th day The skin wound had healed Sutures were removed There were abrasions on the skin which were cleaned and dressed with boric acid powder A fresh plaster cast was applied

Fourth week

The animal was bearing weight on the limb

Fifth week

The animal was bearing weight on the fractured limb

Sixth week

The animal could walk without difficulty after removing the plaster cast The skin wound had healed The animal was sacrificed on the 42nd day The bone was

cropped The callus was well formed and there was no mobility of the fragments (Fig 47 and 48)

Transfixation pins and plaster cast

The cast was changed during the third week when there was oedema of the limb It was hard and firm though discoloured with a patch of blood at one spot After changing the cast, it remained hard and firm for the period of observation The transfixation pins were intact throughout the period of observation

Radiographic observations

After operation

The fragments were in apposition

First week

There was slight displacement of the distal fragment The transfixation pins and plates were in position

Second week

The distal fragment was displaced partially Radiodense zone was observed at the fracture site

Third week

Ossification was observed close to the fracture line and in contact with the proximal and distal fragments The fracture line was less distinct

Fourth week

The fracture gap was covered by a radiodense mass The fracture line was less distinct and the callus showed large areas of ossification

Fifth week

Ossification of the callus was extensive and there was continuity between the ossified callus attached to the two fragments The gap between the two fragments had reduced

Sixth week

Ossification of the callus was marked but there was angulation of the fragments at the fracture site The fracture gap was partially obliterated

Histological observations

Large areas of ossification were observed with the trabeculae arranged similar to cancellous bone Small areas of connective tissue were noticed within the new bone formed Osseous trabeculae were seen on both the sides of the cortical bone indicating ossification of both the internal and external callus (Fig 51 52 53 54 55 56 and 57)

GROUP C

Animal No C 1

The animal was kept under observation for two weeks

Clinical symptoms

First week

The animal was walking without difficulty and could get up and lie down unassisted The animal favoured the limb

Second week

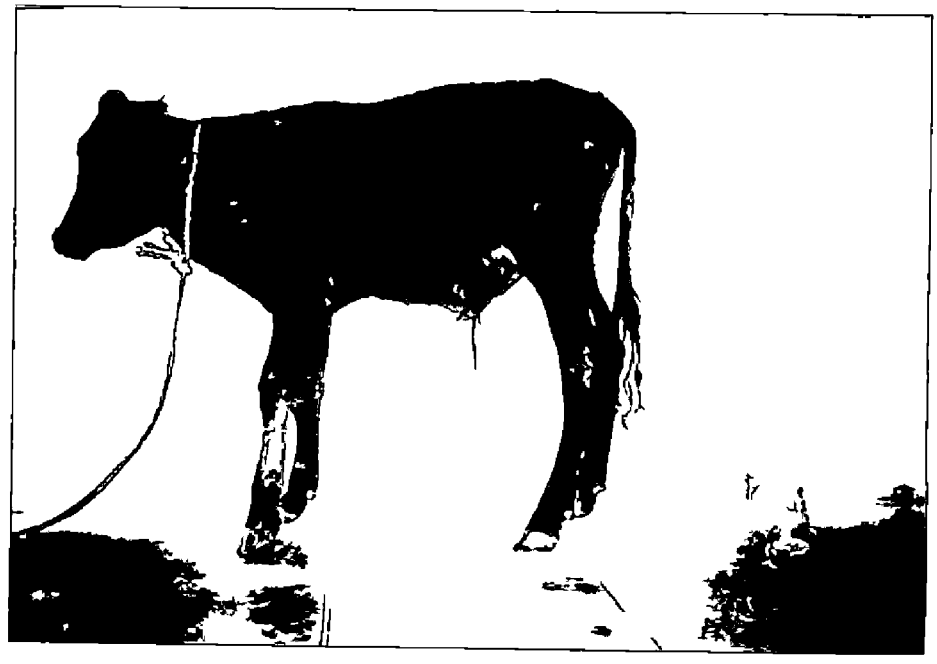
The animal favoured the limb When the cast was removed the surgical wound had healed The animal was sacrificed on the 14th day and the bone was cropped A fibrous callus and a blood clot were present at the site of fracture and there was restricted mobility (Fig 58 and 59)

Cast

The cast was well formed hard and firm The cast remained intact during the period of observation

Fig 57 - Photomicrograph of the callus six weeks after transfixation pinning showing connective tissue (a) and trabeculae of newly formed bone (b)
H & E staining x 160

Fig 58 - Calf - two weeks after immobilisation with gum bandage - the cast has been removed



Radiographic observations

After operation

The fracture fragments were in position (Fig 60)

First week

There was partial displacement of the distal fragment (Fig 61)

Second week

There was partial displacement of the distal fragment (Fig 62)

Histological observations

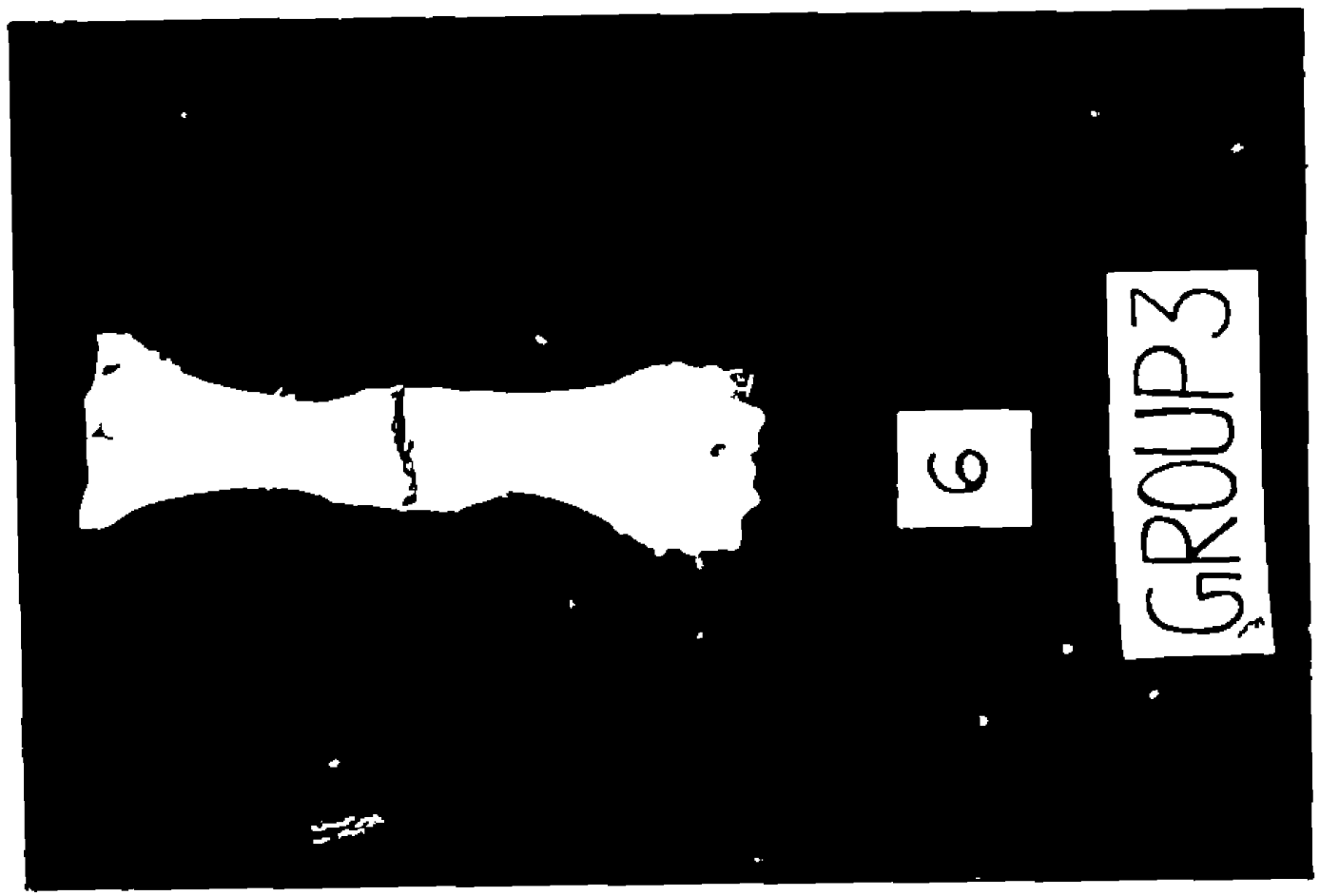
Periosteal and connective tissue proliferation was observed along with inflammatory reaction characterised by cellular infiltration The callus showed areas of ossification close to the cortical bone (Fig 63 64 and 65)

Animal No C 2

The animal was kept under observation for four weeks

Fig 59 - Bone cropped two weeks after immobilisation with gum bandage showing distinct fracture line

Fig 60 Radiograph of the metacarpal region immobilised with gum bandage immediately after operation


GROUP 3
6

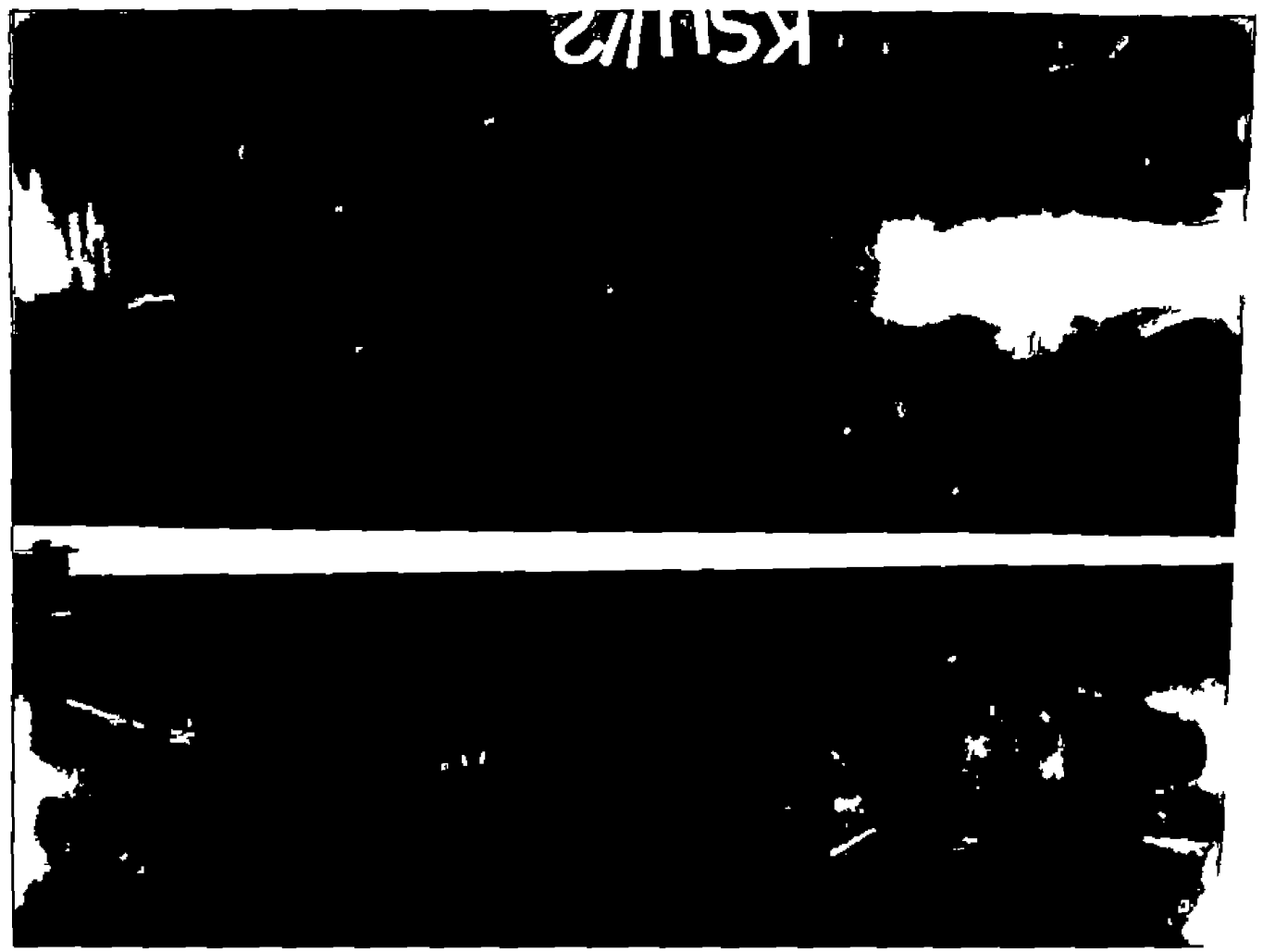


Fig 61 Radiograph of the metacarpal region one week after immobilisation with gum bandage showing the fragments in position with slight angulation

Fig 62 Radiograph of the metacarpal region two weeks after immobilisation with gum bandage showing the fragments in position with slight displacement

KSU 191
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Fig 63 Photomicrograph of the callus two weeks after immobilisation with gum bandage sho wing proliferated connective tissue and periosteum (a)
Thionin staining x 60

Fig 64 Photomicrograph of the callus two weeks after immobilisation with gum bandage showing proliferated connective tissue (a) cellular infiltration (b) and ossification(c)
H & E staining x 160

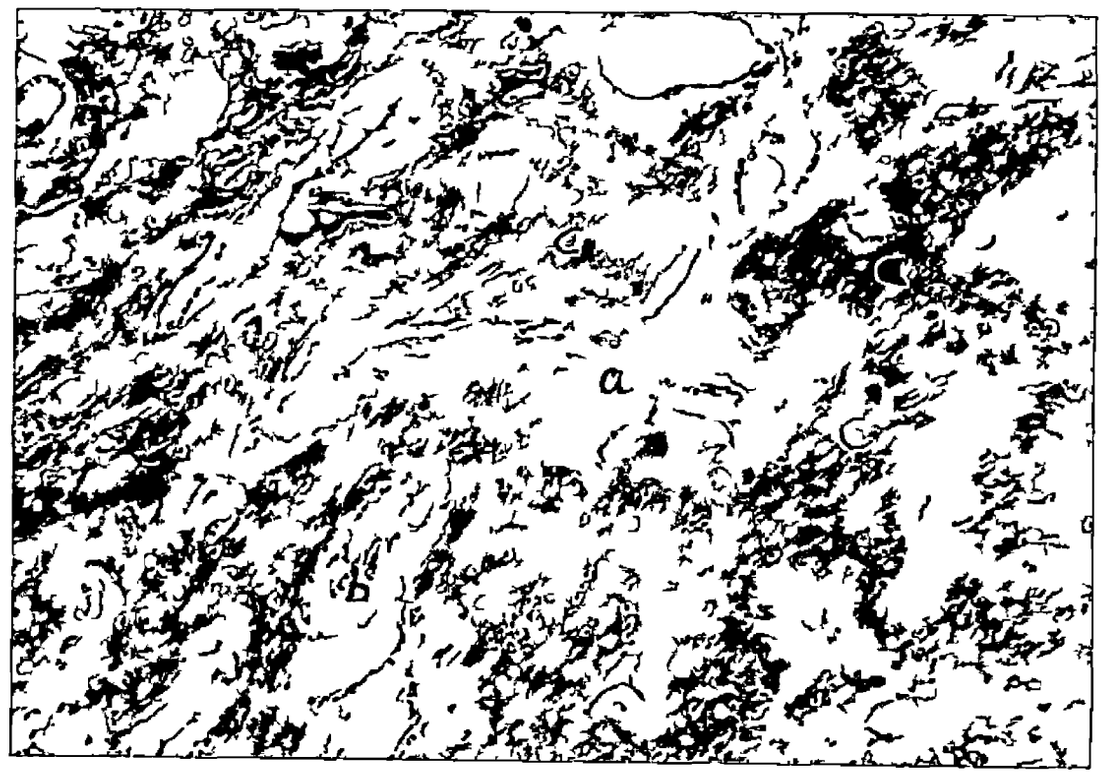

a
b

Fig 65 - Photomicrograph of the callus two weeks after immobilisation with gum bandage showing proliferated connective tissue (a) cellular infiltration (b) and ossification(c) H & E staining x 160


5
GROUP3

Clinical symptoms

First week

The animal could walk without assistance and was able to get up and lie down unaided

Second week

The animal was weak and recumbent most of the time but was taking feed

Third week

The animal was weak and had to be assisted to get up, but walking without difficulty

Fourth week

The animal was weak but was taking feed The surgical wound had healed The animal was sacrificed on the 28th day The bone was cropped There was a well developed callus at the fracture site and mobility was restricted (Fig 66)

Cast

The cast remained firm dry and in place throughout the period of observation

Radiographic observations

After operation

The fragments of bone were in position

First week

The fragments of bone were in position

Second week

The fragments of bone were in position There was a radiodense mass adjacent to the fracture site

Third week

The fragments of bone were in position There was a radiodense mass adjacent to the fracture site (Fig 67)

Fourth week

The fragments of bone were in position There was a radiodense mass adjacent to the fracture site (Fig 68)

Histological observations

The specimen revealed inflammatory changes with large areas of proliferated connective tissue and osseous trabeculae close to the cortical bone (Fig 69 70 71 72 and 73)

Fig 67 - Radiograph of the metacarpal region three weeks after immobilisation with gum bandage showing radiodense area (a) close to the fracture site

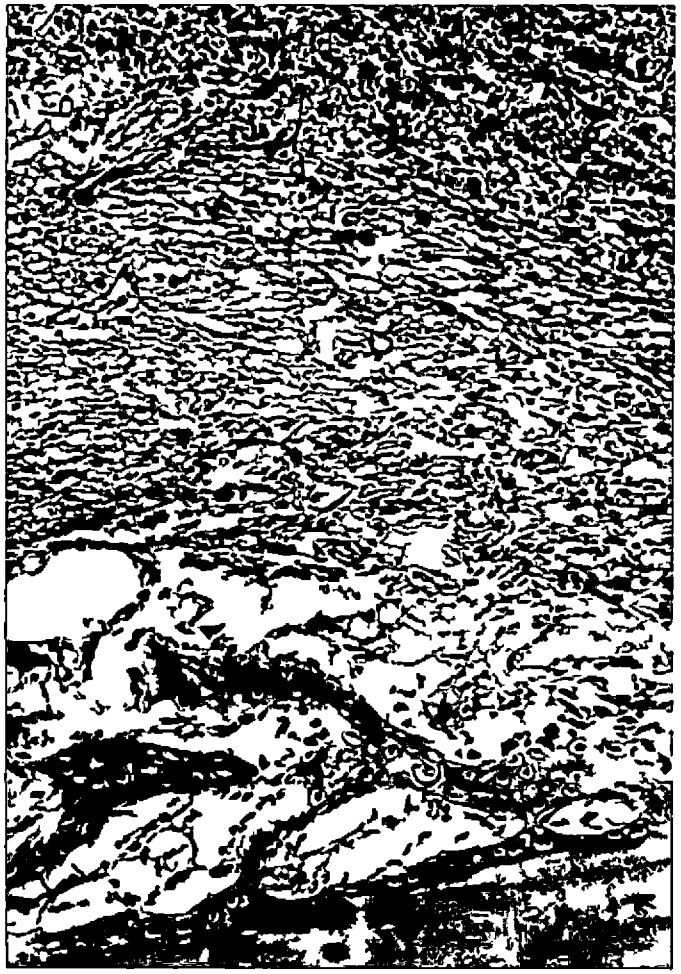
Fig 68 - Radiograph of the metacarpal region four weeks after immobilisation with gum bandage showing partial displacement of the frag ments and ossified callus (a) close to the fracture line

Fig 69 - Photomicrograph of the callus four weeks after immobilisation with gum bandage showing proliferated connective tissue (a) at the fracture site (b)
Thionin staining x 160

Fig 70 - Photomicrograph of the callus four weeks after immobilisation with gum bandage revealing ossified trabeculae of callus (a) close to the cortical bone (b)
Thionin staining x 60

Fig 71 Photomicrograph of the callus four weeks after immobilisation with gum bandage showing proliferated connective tissue (a) cellular infiltration (b) and trabeculae(c) H & E staining x 160

Fig 72 - Photomicrograph of the callus four weeks after immobilisation with gum bandage showing proliferated connective tissue (a) and trabeculae (b) H & E staining x 160



Animal No C 3

The animal was kept under observation for six weeks

Clinical symptoms

First week

The animal could stand up and lie down unaided The animal favoured the limb

Second week

While standing there was pointing of toes It showed signs of pain and lameness during walking

Third week

There was pointing of the toes while standing While walking, it dragged the toes

Fourth week

There was no improvement and lameness was more pronounced

Fifth week

The cast was removed on the 30th day because it was damaged There was a small quantity of pus at the

suture line There was a wound on the medial aspect of the knee and oedema at the posterior aspect of the pastern The wounds were cleaned and dressed with boric acid powder and bandaged The limb was immobilised using splints and bandages

Sixth week

The wound was dressed daily and bandaged The animal was not bearing weight on the limb rested the limb on the toes and kept the limb abducted The animal was sacrificed on the 42nd day and cropped the bone (Fig 74 and 75) Suppuration was extending into the callus The callus was well developed but there was restricted mobility

Cast

The cast became sticky and moist in the first week It was removed during the fifth week when it was damaged

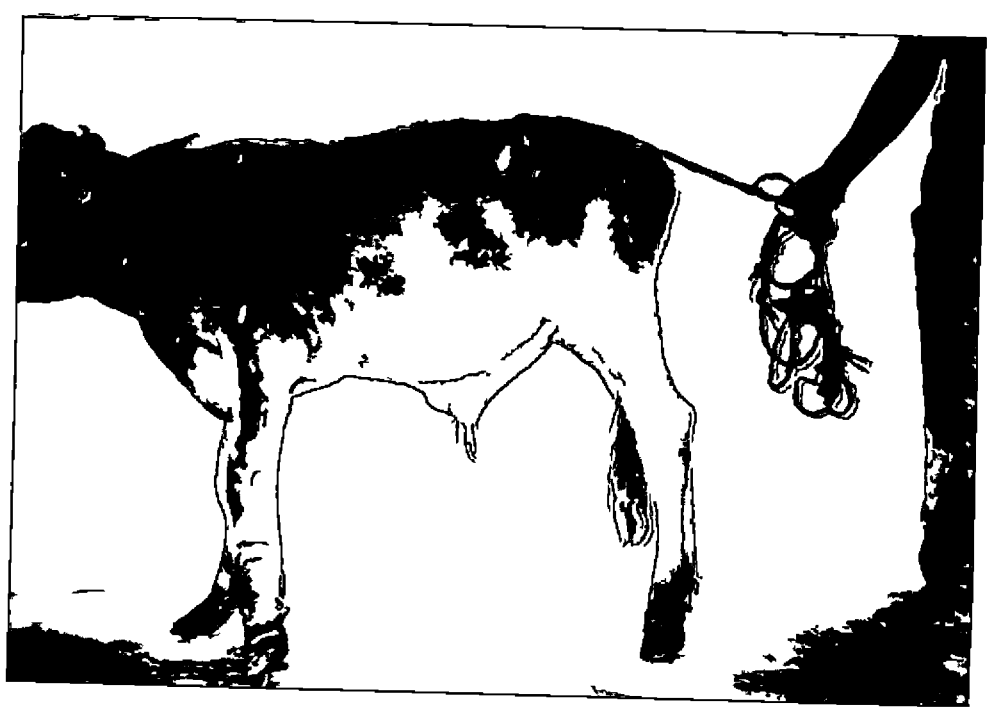
Radiographic observations

After operation

The fragments were in position

Fig 73 Photomicrograph of the callus four weeks after immobilisation with gum bandage showing cellular infiltration (a) proliferated blood vessels and connective tissue (b) H & E staining x 160

Fig 74 Animal number C3 six weeks after immobili sation with gum bandage the cast was removed A wound seen at the fracture site



First week

The fragments were in position but there was partial displacement of the distal fragment

Second week

The fragments were in position and the displacement persisted

Third week

The fragments were in position and the displacement persisted

Fourth week

Zones of ossification were noticed close to both the fragments There was slight angulation at the fracture site

Fifth week

Ossification of the callus was marked but the fragments were displaced Apposition between the fragments was less than 50 per cent

Sixth week

The callus showed large areas of ossification but with no union of the fragments (Fig 76)

Histological observations

Zone of suppuration along with proliferated connective tissue and capillaries was observed Ossifica tion of the callus with trabeculae continuous with the cortical bone was also noticed The callus was not completely ossified and contained large areas of connective tissue (Fig 77, 78 and 79)

Animal No C 4

The animal was kept under observation for six weeks

Clinical symptoms

First week

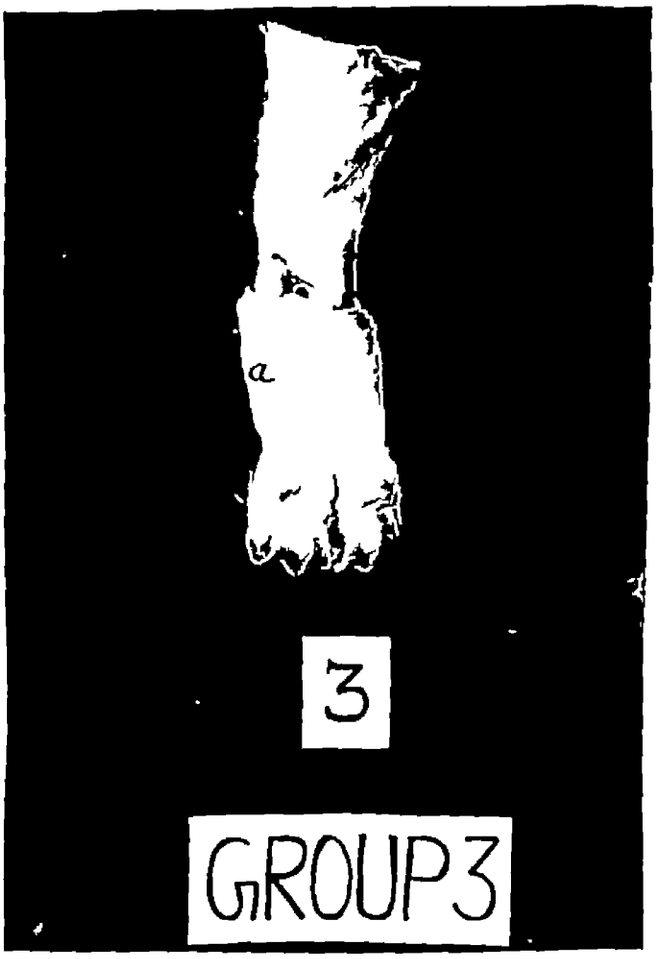
The animal was walking getting up and lying down unaided

Second week

The animal favoured the limb

Fig 75 - Bone cropped from animal C3 six weeks after immobilisation with gum bandage Thickening of the shaft due to callus formation is seen (a)

Fig 76 - Radiograph of the metacarpal region six weeks after immobilisation with gum bandage in animal C3 showing marked displacement of the fragments and a callus at the fracture site


a
3
GROUP3


ASU 109

Fig 77 - Photomicrograph of the callus at six weeks in animal C3 showing proliferated connective tissue (a) and areas of ossified callus (b) H & E staining x 160

Fig 78 Photomicrograph of the callus at six weeks in animal C3 showing extensive proliferation of connective tissue (a) ossification with trabeculae formation (b) H & E staining x 60


b
b


a
b
b

Third week

The animal showed no sign of pain or discomfort on manipulation of the limb

Fourth week

The animal could get up and lie down unaided

Fifth week

The animal had no difficulty in walking and in getting up and lying down

Sixth week

The animal favoured the limb after the cast was removed Two ulcers were observed at the pastern The skin wound had healed Sacrificed the animal on the 42nd day and cropped the bone The callus was well developed and the fragments have united (Fig 80 81 and 82)

Cast

The cast was damp initially but later it dried up and became hard and firm The cast remained intact throughout the period of observation

Fig 79 Photomicrograph of the callus at six weeks in animal C3 showing suppuration within the callus (a) surrounded by proliferated connective tissue (b) and blood vessels H & E staining x 60

Fig 80 - Calf Six weeks after immobilisation with gum bandage showing thickening of the limb

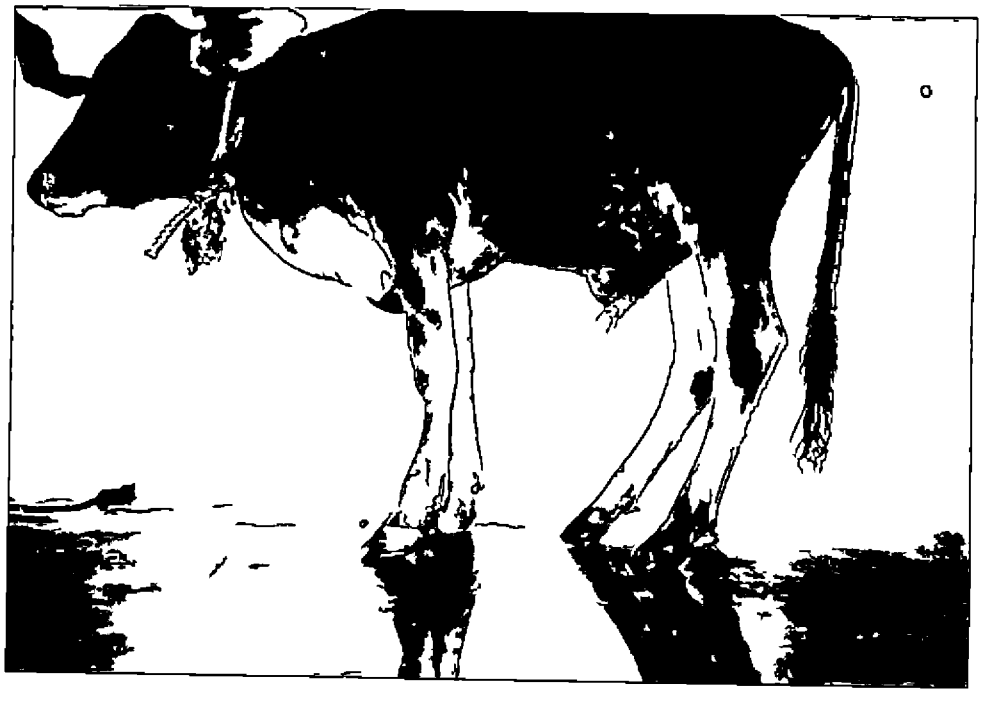


Fig 81 - Bone cropped six weeks after immobilisation with gum bandage showing well developed callus

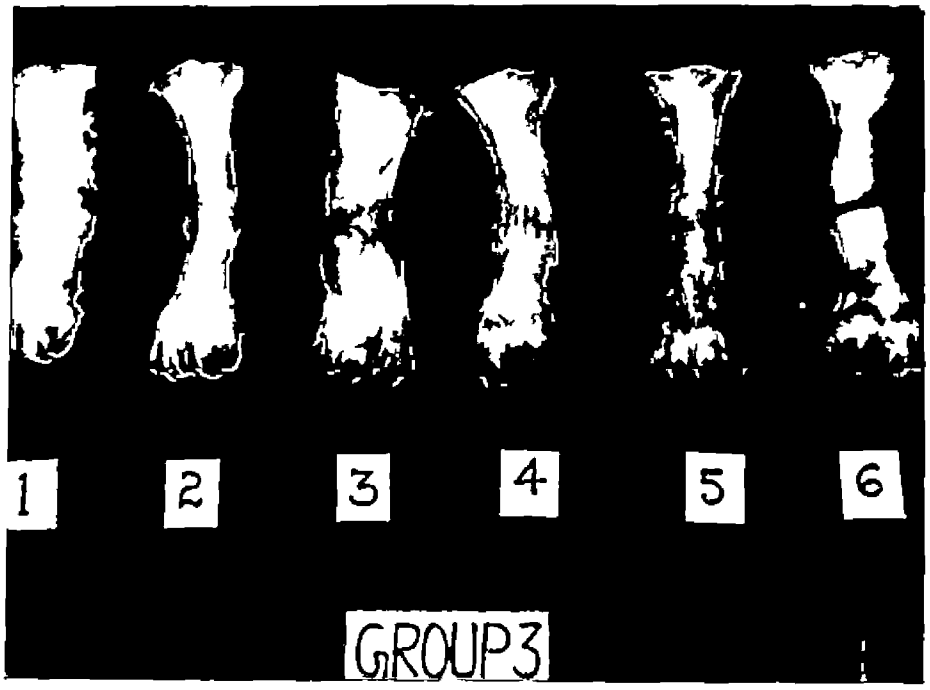
Fig 82 Bones cropped in Group C -

1 4 Six weeks after immobilisation

5 Four weeks after immobilisation

6 Two weeks after immobilisation


2
GROUP3


1
2
3
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5
6
GROUP3

Radiographic observations

After operation

The fragments were in position

First week

The fragments were in position There was slight angulation at the fracture site

Second week

Radiodense area was observed at the fracture site The fragments were in position

Third week

Ossification of the callus was noticed close to the fragments

Fourth week

Moderate ossification of the callus was observed

Fifth week

Moderate ossification of the callus was noticed and the fracture line was less distinct (Fig 83)

Sixth week

The callus was ossified and was continuous between the fragments The fracture line was partially obliterated (Fig 84)

Histological observations

Large areas of proliferated connective tissue and ossification were observed The trabeculae were continuous with the cortical bone and the callus resembled cancellous bone (Fig 85 86 87 and 88)

Animal No C 5

The animal was kept under observation for six weeks

Clinical symptoms

First week

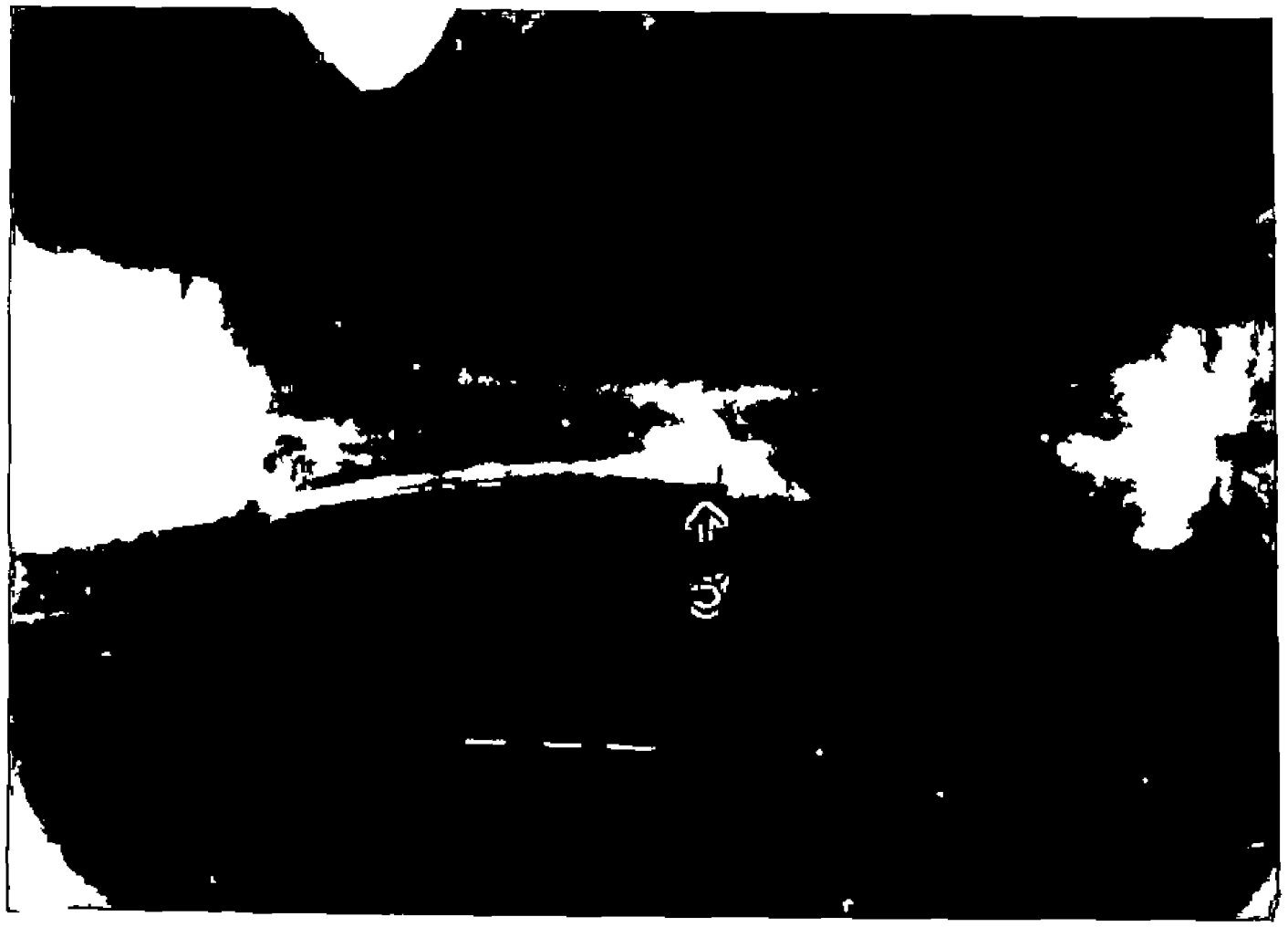
The animal could stand up and lie down unaided

Second week

The animal favoured the fractured limb The animal was dragging the toes while walking

Fig 83 - Radiograph of the metacarpal region five weeks after immobilisation with gum bandage showing ossified callus (a) and partial obliteration of the fracture line

Fig 84 Radiograph of the metacarpal region six weeks after immobilisation with gum bandage showing partial displacement of fragments(a) ossified callus uniting the fragments and partial obliteration of fracture line



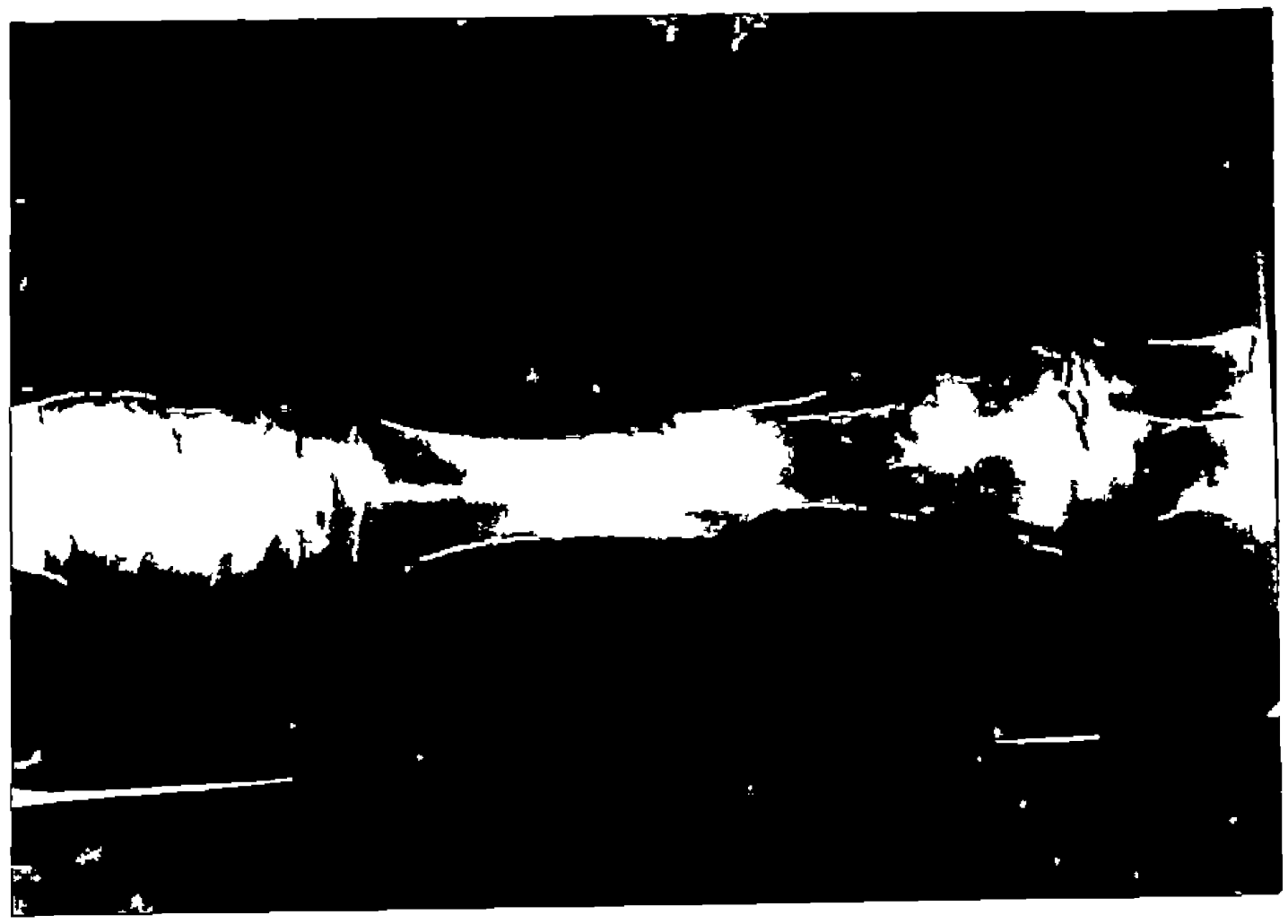


Fig 85 Photomicrograph of the callus six weeks after immobilisation with gum bandage showing highly vascular connective tissue (a) and ossification close to the cortical bone (b)
H & E staining x 160

Fig 86 - Photomicrograph of the callus six weeks after immobilisation with gum bandage showing ossification close to the cortical bone (a)
H & E staining x 160

Third week

The animal was dragging the toes It was able to stand up and lie down unaided

Fourth week

The animal could walk and showed no sign of pain There was slight oedema below the cast The cast was cut longitudinally at the distal end to relieve pressure On the 27th day, the cast was removed The skin wound had healed The skin sutures were removed and fresh cast was applied

Fifth week

The animal was walking without difficulty but was favouring the fractured limb

Sixth week

The animal was walking fast though favouring the limb It showed no sign of pain After the cast was removed the animal was walking bearing weight on the limb There was a wound at the pastern region The animal was sacrificed on the 42nd day and the bone was cropped The callus was well developed and the fragments united (Fig 82)

Cast

The upper and lower parts of the cast were dry but the middle part was moist and sticky During the fourth week, the cast was changed After that it remained intact and firm for the period of observation

Radiographic observations

After operation

The fragments were in position

First week

There was angulation of the bone at the fracture site

Second week

Radiodense area was observed at the fracture site

Third week

Zones of ossification were observed in the callus close to the proximal and distal fragments The fracture line was less distinct

Fourth week

Marked ossification of the callus was apparent close to both the fragments The ossified callus was continuous between the two fragments The fracture line was less distinct

Fifth week

The ossification of the callus was marked The fracture line was partially obliterated The callus was continuous between the two fragments

Sixth week

Ossification of the callus was extensive The fracture line was partially obliterated

Histological observations

Large areas of proliferating connective tissue and ossification were observed The osseous trabeculae were continuous with the cortical bone and the callus resembled cancellous bone Areas of highly vascular connective tissue were observed along with osseous callus (Fig 85 86 87 and 88)

Animal No C 6

The animal was kept under observation for six weeks

Clinical symptoms

First week

The animal could stand up and lie down unaided It showed signs of pain when the limb was manipulated

Second week

The animal favoured the limb and dragged the toes

Third week

The animal could stand up and lie down unaided It could walk without difficulty though it favoured the fractured limb

Fourth week

While walking the limb was used without difficulty

Fifth week

The cast had become loose and the splints were displaced The cast was removed and a wound was noticed on the medial aspect of the knee The sutures were removed the wounds cleaned and dressed and a fresh cast was applied

Sixth week

The animal favoured the limb but it was walking without difficulty The animal was sacrificed on the 42nd day The bone was cropped The callus was well developed and fragments were united (Fig 82)

Cast

The cast was firm in the first week but became wet in the second week It was changed during the fifth week and this cast remained firm hard and dry

Radiographic observations

After operation

The fragments were in position

First week

The fragments were in position but there was partial displacement of the distal fragment

Second week

A radiodense area was observed close to the fragments in the vicinity of the fracture

Third week

Ossification was noticed in the callus at the fracture site

Fourth week

Marked ossification of the callus was apparent The fracture line was less distinct

Fifth week

The callus was well formed and ossification was extensive The callus was continuous between the two fragments The fracture line was partially obliterated

Sixth week

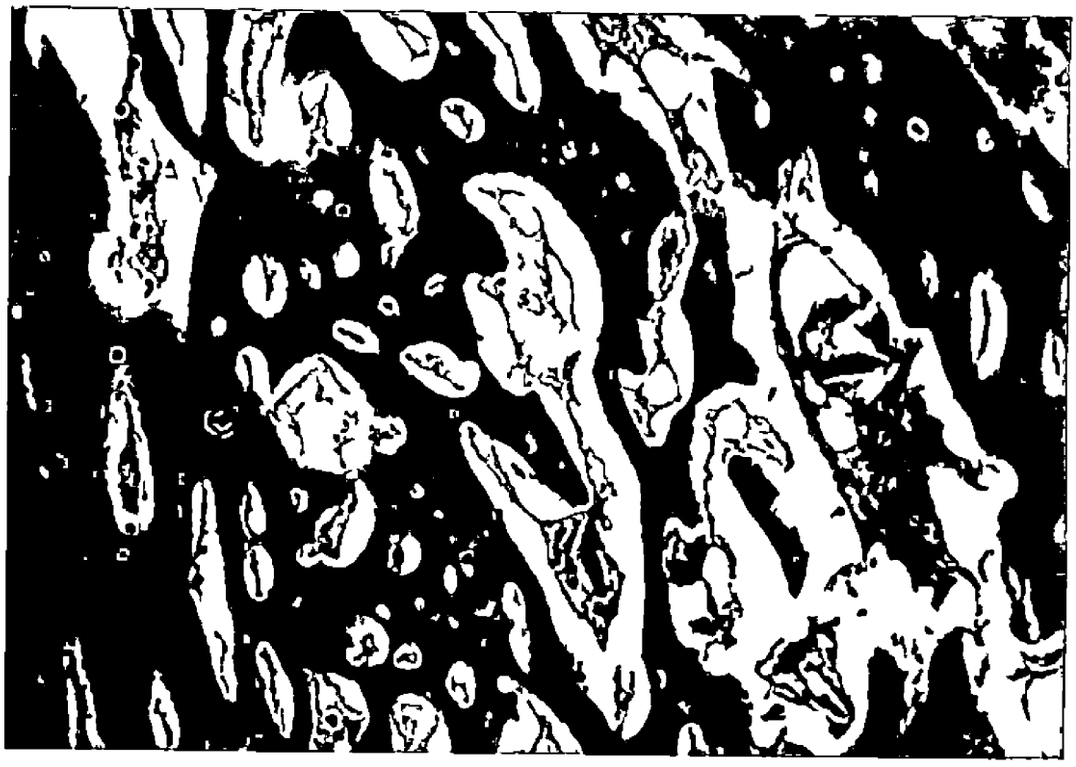
The callus showed extensive ossification and the callus of the two fragments had united The fracture line was partially obliterated

Histological observations

The callus showed extensive areas of proliferated connective tissue and ossification The osseous trabeculae were continuous with the cortical bone and resembled cancellous bone (Fig 85 86 87 and 88)

Fig 87 - Photomicrograph of the callus six weeks after immobilisation with gum bandage showing trabeculae (a) continuous with the cortical bone
H & E staining x 60

Fig 88 Photomicrograph of the callus six weeks after immobilisation with gum bandage showing osseous trabeculae (a) continuous with the cortical bone
Thionin staining x 60



Discussion

DISCUSSION

The study was conducted on 18 crossbred male calves divided in three groups of six animals each Under local anaesthesia (ring block) fracture was created at the midshaft region of the large metacarpal and was reduced The limb was immobilised with (i) plaster of Paris cast (Group A) (ii) Transfixation apparatus and plaster of Paris cast (Group B) and (iii) cast using freshly prepared gum and bandages (Group C)

The technique of anaesthesia (ring block) was satis factory for induction of fracture of the metacarpus in all the animals

The cast applied with plaster of Paris or gum and bandages became hard, firm and dry and was satisfactory for immobilisation All the animals of Group A B and C except animal A4 were bearing weight on the limb and could get up and lie down unassisted by the first week

The following clinical symptoms were observed in the experimental animals

a) Favouring the limb

b) Pointing of the toes

c) Dragging of the toes and

d) Oedema during the period of observation

Four animals of Group A, two animals of Group B and three animals of Group C favoured the limb throughout the period of observation

Pointing of the toes was noticed in three animals of Group A two animals of Group B and one animal of Group C

Dragging of the toes was noticed in three animals each of Group A and C

Oedema was observed at the pastern region after immobilisation in animals A1 and A2 of Group A during the first week but it disappeared when the pressure of the cast was relieved In Group B oedema was observed in four animals Animal numbers B1 and B2 had oedema at the fetlock and pastern during the first week which subsi ded in the second week and third week respectively Animal numbers B5 and B6 had oedema at the fetlock and pastern in the third week and it subsided when the pressure of the cast was relieved In Group C only two animals developed oedema at the pastern Animal number C3 developed oedema in the fifth week and C5 in the

fourth week which subsided when the pressure of the cast was relieved Oedema distal and proximal to the plaster cast/immobilising dressing in the treatment of fracture has been reported by Leonard (1960) and Fessler and Amstutz (1974)

The plaster cast remained intact in animal number A1 throughout the period of observation It had to be changed once in animals A2 A3 and A6 and twice in animals A4 and A5 In Group B the cast remained intact during the period of observation in animal B3 it had to be changed once in animals B1 B4 and B6 and twice in animals B2 and B5 In Group C the cast remained intact during the period of observation in animals C1 C2 and C4 and had to be changed once in animals C3 C5 and C6 The cast when applied with plaster of Paris became damaged and had to be changed in ten out of twelve animals whereas the cast applied with gum bandages had to be changed only in three out of the six animals

Radiographic studies revealed radiodense areas at the fracture site by the first week only in animal number A1 By the second week it was observed in four animals each of Group A B and C By the third week all the animals except C3 showed radiodense areas and by the

fourth week it was observed in all the animals Singh (1978) reported periosteal reaction in both segments of the bone by the second week when simple coaptation with plaster of Paris cast and aluminium strips were used Singh and Nigam (1979) stated that in simple coaptation there was slight periosteal reaction and blurring of the fracture gap by the second week and periosteal bone formation with moderate periosteal reaction by the fourth week Ayyappan (1981) reported periosteal proliferation by the third week when intramedullary pinning was employed as a method of immobilisation in calves

Radiodense areas were observed close to the fracture site by the third week in all the animals The fracture line had become less distinct in one animal of Group A two animals of Group B and one animal of Group C

Ossification of the callus was noticed in all the animals by the fourth week The fracture line was less distinct in all the animals of Group A three animals of Group B and two animals of Group C

Ossification of the callus and its union was noticed by the fifth week in all the animals except C3 in which

ossification of the callus was present but the fragments were displaced and apposition between the fragments was less than 50 per cent However, in Group B ossification of the callus was more extensive Partial obliteration of the fracture line was seen in all the animals except A4 B5 and C3

Ossification of the callus was more extensive by the sixth week and the callus was continuous between the two fragments with the fracture line partially obliterated in all the animals of Group A B and C except C3 in which union of the callus was not noticed These observations are in agreement with the observations of Singh (1978) and Singh and Nigam (1979) who noticed that by the sixth week the fracture line was only partially obliterated Ayyappan (1981) reported that the ossified callus was continuous and the fracture line was partially obliterated by the fifth week when intramedullary pinning was done

In the animals kept under observation for two weeks the bone cropped from animal A1 showed that the fragments were not united and there was mobility at the fracture site whereas in animal B1 and C1 a blood clot was

noticed in between the two fragments which were in apposition and with restricted mobility In the animals kept for four weeks viz A2 B2 and C2 a well developed soft callus was observed at the fracture site and there was restricted mobility In all the animals kept for six weeks the callus was well developed suggestive of clinical union with no mobility at the fracture site except animal number C3 In animal C3 the callus was well developed but there was no clinical union

Microscopic examination of the callus cropped at the second week in Group A revealed periosteal and capillary proliferation adjacent to the fracture with zones of necrosis of cortical bone at the fracture site In group B and C the proliferative changes of periosteum and blood vessels were more marked and zones of ossification of the callus was also observed

The callus cropped at the fourth week revealed marked connective tissue and capillary proliferation along with zones of ossification and formation of osseous trabeculae in group A The callus in animals of group B revealed extensive ossification and osseous trabeculae formation with smaller areas of fibrous tissue blood

vessels and inflammation In Group C zones of ossifica tion fibrous tissue proliferation and vascular proli- feration were observed in the callus along with inflamma- tory reaction

In the animals kept under observation for six weeks the callus revealed zones of hyaline cartilage in the animals of group A The areas of ossification were extensive and were characterised by formation of interconnected trabeculae of bone attached to the cortical bone In group B large areas of interconnected osseous trabeculae similar to cancellous bone ossifica tion of external and internal callus and zones of inflammatory changes were observed Hyaline cartilage in the callus was observed only in animal No B4 In group C the callus revealed proliferating highly vascular connective tissue along with trabecular ossifi cation centres The trabeculae were continuous with the cortical bone In animal C3 there were zones of suppura tion and the callus contained large areas of connective tissue with scattered zones of ossification

Suppuration at the suture line extending upto the callus was observed in the animal C3 Hamilton and

treatment in animals and by Rao *et al* (1985) who reported that simple coaptation was associated with displacement of fragments

Tulleners (1980) had reported infection as a complication in transfixation pinning in calves Singh et al (1984) reported that infection and malalignment were the most common postoperative complications after external and internal immobilisation of fractures in animals In the present study infection was noticed only in one of the calves where external immobilisation was adopted

Partial displacement of the fragments after immobilisation was noticed in two animals in Group A viz A3 and A6 three animals in Group B viz B3 B5 and B6 and four animals in Group C viz C1 C3 C5 and C6 All the animals except C1 were sacrificed at six weeks and C1 was sacrificed at two weeks However the callus formation and ossification had taken place in these animals and at six weeks the callus was well developed and the fragments were united Ayyappan (1981) observed displacement of fragments when plaster of Paris reinforced with bamboo splints were used for immobilisation in fractures of tibia in calves Similar observations were made by Singh et al (1984) who reported that malalignment was a common postoperative complication in fracture

Summary

SUMMARY

The study was conducted on 18 crossbred male calves divided in three groups of six animals each Under local anaesthesia (ring block) fracture was created at the midshaft region of the large metacarpal and was reduced The limb was immobilised with (i) plaster of Paris cast (Group A) (ii) Transfixation apparatus and plaster of Paris cast (Group B) and (iii) cast using freshly prepa red gum and bandages (Group C)

The animals were kept under observation upto six weeks One animal from each group was sacrificed at the second week and fourth week and the remaining animals at the sixth week

Oedema was observed distal to the cast in two animals each in Group A and C and four animals in Group B

Pointing of the toes was noticed in three animals of Group A two animals of Group B and one animal of Group C

Dragging of the toes was noticed in three animals each of Group A and C

All the animals except one from Group A were bearing weight on the limb and could get up and lie down unassisted by the first week

Four animals of Group A two animals of Group B and three animals of Group C favoured the limb throughout the period

In Group A and B the plaster cast remained intact throughout the period of observation in one animal had to be changed once in three animals and twice in two animals In Group C the cast remained intact throughout the period of observation in three animals and was changed once in three animals

Radiodense area was observed at the fracture site in one animal by the first week in four animals of each group by the second week and in all animals except one by the third week and in all the animals by the fourth week

The fracture line had become less distinct in one animal of Group A two animals of Group B and one animal of Group C by the third week

Ossification of the callus was noticed in all the animals by the fourth week The fracture line was less distinct in all the animals of Group A three animals of Group B and two animals of Group C

Ossification of the callus and its union was noticed by the fifth week in all the animals except one animal of Group C However in Group B, ossification was more extensive Partial obliteration of the fracture line was seen in all except three animals

Extensive ossification of the callus with continuity between the callus of the two fragments and partial obliteration of the fracture line was observed in all the animals except one animal of Group C by sixth week

The fractured bone cropped after two weeks revealed that in group A the fragments were separate and there was mobility at the fracture site but in Group B and C mobility was less

Soft callus between the fragments and restricted mobility at the fracture site was noticed in the bones cropped at four weeks in animals of all the groups

The callus was well developed and the fragments were firmly fixed by the callus in the bones cropped at six weeks in all the animals of Group A and B and in three animals of Group C

Microscopic examination of the callus at two weeks revealed periosteal and capillary proliferation with zones of necrosis of cortical bone at the fracture site in Group A In Group B and C the proliferative changes were more marked along with zones of ossification

The callus cropped at four weeks revealed marked connective tissue and capillary proliferation along with zones of ossification and formation of trabeculae in Group A and C and in Group B ossification was more extensive

Extensive ossification and interconnected trabeculae continuous with the cortical bone was observed in the callus cropped at six weeks in all the three groups Zones of hyaline cartilage were

observed in the callus in the animals of Group A and one animal of Group B and zone of suppuration in one animal of Group C

Suppuration at the suture line involving the callus and fracture site was observed in one animal of Group C

Partial displacement of the fragments after immobilisation was noticed in two animals of Group A three animals of Group B and four animals of Group C

The following conclusions could be drawn from the study

1 All the three techniques viz plaster of Paris cast transfixation pinning with plaster cast and cast with gum bandages employed for external immobilisation in the present study were found to be satisfactory

2 Progress of healing evaluated by macroscopic radio graphic and microscopic examination was comparable in the three techniques

3 Partial displacement of fragments observed in some of the animals did not interfere with the progress of healing and the ability to use the limbs

4 Gum (consisting of black gram powder rock salt papadakaram water egg white and lime juice) bandage cast applied for immobilisation was found to be a suitable substitute for plaster of Paris cast

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COMPARATIVE STUDY OF HEALING OF FRACTURE OF METACARPUS IN CALVES USING DIFFERENT EXTERNAL IMMOBILISATION METHODS

By

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ABSTRACT OF A THESIS

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ABSTRACT

The study was conducted on 18 crossbred male calves divided in three groups of six animals each Under local anaesthesia (ring block) fracture was created at the midshaft region of the large metacarpal and was reduced The limb was immobilised with (i) plaster of Paris cast (Group A) (ii) Transfixation apparatus and plaster of Paris cast (Group B) and (iii) cast using freshly prepared gum and bandages (Group C)

The animals were kept under observation upto six weeks One animal from each group was sacrificed at the second week and fourth week and the remaining animals at the sixth week

Oedema was observed distal to the cast in two animals each in Group A and C and four animals in Group B

Pointing of the toes was noticed in three animals of Group A two animals of Group B and one animal of Group C

Dragging of the toes was noticed in three animals each of Group A and C

All the animals except one from Group A were bearing weight on the limb and could get up and lie down unassisted by the first week

Four animals of Group A two animals of Group B and three animals of Group C favoured the limb through out the period

In Group A and B the plaster cast remained intact throughout the period of observation in one animal had to be changed once in three animals and twice in two animals In Group C the cast remained intact through out the period of observation in three animals and was changed once in three animals

Radiodense area was observed at the fracture site in one animal by the first week in four animals of each group by the second week and in all animals except one by the third week and in all the animals by the fourth week

The fracture line had become less distinct in one animal of Group A two animals of Group B and one animal of Group C by the third week

Ossification of the callus was noticed in all the animals by the fourth week The fracture line was less distinct in all the animals of Group A three animals of Group B and two animals of Group C

Ossification of the callus and its union was noticed by the fifth week in all the animals except one animal of Group C However in Group B ossification was more extensive Partial obliteration of the fracture line was seen in all except three animals

Extensive ossification of the callus with continuity between the callus of the two fragments and partial obliteration of the fracture line was observed in all the animals except one animal of Group C by sixth week

The fractured bone cropped after two weeks revealed that in Group A the fragments were separate and there was mobility at the fracture site but in Group B and C mobility was less

Soft callus between the fragments and restricted mobility at the fracture site was noticed in the bones cropped at four weeks in animals of all the groups

The callus was well developed and the fragments were firmly fixed by the callus in the bones cropped at six weeks in all animals of Group A and B and in three animals of Group C

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The callus cropped at four weeks revealed marked connective tissue and capillary proliferation along with zones of ossification and formation of trabeculae in Group A and C, and in Group B ossification was more extensive

Extensive ossification and interconnected trabeculae continuous with the cortical bone was observed in the callus cropped at six weeks in all the three groups Zones of hyaline cartilage were observed in the callus in the animals of Group A and one animal of Group B and zone of suppuration in one animal of Group C

Suppuration at the suture line involving the callus and fracture site was observed in one animal of Group C

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