THE COMPARISON OF FEMORAL FRACTURE REPAIR IN YOUNG CALVES

by

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INTRODUCTION

Long bone fractures have long been a problem in large animal species. This problem has been prevalent in the past few years in the cattle industry apparently due to the crossbreeding programs with European or "Exotic" breeds with resultant oversized fetuses and accompanying dystocias. The weight-bearing stresses and muscle pull make it extremely difficult to immobilize the fracture and allow healing. Sepsis has also been a significant problem during the healing period when using internal fixation devices.

Some success has been found in treatment of fractures of the lower limbs, distal to the stifle and elbow using a combination of internal and external immobilization.[3,8,9] However, the humerus and femur still present a problem of stable immobilization.

THE COMPARISON OF FEMORAL FRACTURE REPAIR IN YOUNG CALVES

Introduction

Five cases of fractured femur in calves less than 1 week of age were presented to Dykstra Veterinary Hospital, Manhattan, Kansas in a period of 13 months. All were corrected with internal fixation. One had "Rush" pins and a screw, one had a bone plate, and three had intramedullary pins. None of the calves healed satisfactory and all died or were euthanatized because of osteomyelitis (2), lameness (1), anesthetic death (1), fracture non-union (1) respectively. This stimulated a further study of femoral fracture repair in young calves.

Material and Methods

Twelve Holstein bull calves were purchased from a dairy in Kansas. They were less than 1 week old when purchased and weighed from 80 to 100 pounds. Upon arrival they were treated with Serogen L.A.,[a] Multibex C,[b] and Panmycin.[c] They were kept on treatment until all evidence of enteritis had subsided.

A blood profile was performed on each calf including complete blood count, total protein, serum dehydrogenase, fibrinogen, sodium, potassium, chloride, carbon dioxide, blood urea nitrogen, alkaline phosphatase, albumin, calcium, inorganic phosphorus, glucose, creatinine.

The calves were fed milk replacer[e] twice daily via nipple bucket.

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[a] Serogen L.A., Diamond Laboratories Inc., Des Moines, IA 50304

[b] Multibex C, Eli Lilly & Co., Indianapolis, IN 46206

[c] Panmycin Hydrochloride, The Upjohn Co., Kalamazoo, MI 49001

[e] Milk Saver, Farmland Industries, Kansas City, MO

The calves were prepared for surgery by withholding feed the day of the procedure. A pre-anesthetic injection of .02 mg per pound of Atropine[g] sulfate was administered subcutaneously. Anesthesia was induced with thiamylal sodium[h] IV at a dosage of 3 mg per pound, or to affect. An endotracheal tube was inserted and the calves maintained on an inhalatory anesthetic mixture of halothane[i] and oxygen. Lactated Ringers Solution[r] was administered by slow IV drip throughout the procedure.

The calf was placed in left lateral recumbency and the right rear leg was prepared for surgery. The hair was clipped and surgically scrubbed with Septodyne scrub.[w] Septodyde solution,[x] a skin antiseptic, was sprayed over the surgical site.

A lateral approach was made to the femur by incising the skin and subcutaneous fascia. The aponeurosis between the biceps femorus muscle and tensor fascia lata was incised and the vastas lateralis muscle elevated from the bone to expose the entire lateral aspect of the diaphysis of the femur.

The femur was fractured by drilling 4 holes transversely through the bone at the midshaft area with a 3/16" Steinman pin.[v] The edge of a Bard Parker scalpel handle was placed over the weakened area and struck with a mallet to produce a transverse, midshaft fracture. The

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[g]Atropine, Burroughs Wellcome Co., Research Triangle Park, NC 27709

[h]Surital, Park Davis & Co., Detroit, MI 48232

[i]Fluothane, Ayerst Laboratories, New York, NY 10017

[r]Lactated Ringers Solution, Travenol Laboratories Inc., Deerfield, IL 60015

[w]Septodyde Scrub, Winthrop Laboratories, New York, NY 10016

[x]Septodyne Solution, Winthrop Laboratories, New York, NY 10016

[v]Steinman Pin, Kirschner Manufacturing Co., Vashon, WA

fracture was manually manipulated and distracted and then repaired in one of three methods.

Five calves were fixed using multiple 1/4" and 3/16" intramedullary pins[v] inserted in a retrograde fashion. The fracture was reduced and the pins driven into the distal fragment using a mallet and punch. One of the 5 calves was fitted with a modified Thomas splint to keep the leg in extension. Two of the 5 calves had no external fixation, and 2 calves were placed in an Ehmer sling to keep the leg in flexion.

Three calves had a Kirschner apparatus[u] placed on the fractured femur. Each fragment had at least 2 pins placed transversely and were attached externally by means of a metal bar. One of the calves was fitted with a modified Thomas splint, one with an Ehmer sling, and one with no external fixation.

Three calves had a 6 or 7 hole standard ASIF Broad Plate[t] and standard cortical screws[t] used to stabilize the fracture. At least 3 screws were placed in each fragment. One of these calves was placed in a modified Thomas splint. One was placed in an Ehmer sling, and one had no external fixation.

One calf was used as a control and had no internal fixation device (the femur of this animal was immobilized with a modified Thomas splint).

The surgical site was bathed in 1 million units of potassium penicillin[j] and closed using #1 gut.[k] The muscles and fascia were closed

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[u]Kirschner Apparatus, Kirschner Manufacturing Co., Vashon, WA

[t]ASIF Bone Plates & Screws, Synthes L.T.D., Wayne, PA 19087

[j]Crystalline Penicillin, E. R. Squibb & Son Inc., Princeton, NJ 08504

[k]Ethicon, Ethicon Inc., Somerville, NJ 08876

with a simple continuous pattern and the skin was closed with heavy Vetafil[1] in an interlocking pattern.

Radiographs were taken immediately postoperatively and on day 14, 28, and 42.

The calves were started on antibiotic therapy and were monitored daily for temperature, appetite, fecal character, and the ability to move. Antibiotics were given as long as there was a fever or the calf showed evidence of enteritis or infection.

The calves were euthanatized on day 42 with saturated $MgSO_4$ I.V. and a necropsy performed. The femur was removed and photographed. The bone was sectioned sagittally and re-photographed.

The fracture site was then removed, decalcified, sectioned, and stained for histopathological studies.

Results

The control calf (741) died on day 12. Possibly due to inadequate splintage and the weakened condition of the calf he never stood and on post mortem showed no evidence of healing. Death was attributed to pneumonia.

Two calves with intramedullary pins[v] died before the end of the scheduled experiment. Calf number 744 had no external fixation and died on day 12 of pneumonia. He had been able to walk on the affected leg prior to his death. Calf No. 740 which was in an Ehmer sling died on day 3 of pneumonia and enteritis. Prior to death he was able to stand with assistance but not alone. Neither of these calves showed any healing.

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[1]Vetafil, S. Jackson Inc., Washington, D.C. 20014

The 3 calves with intramedullary pins[V] which survived until the end of the experiment all showed evidence of healing by callus formation. Calf No. 736 which had 3 intramedullary pins[V] and a modified Thomas splint walked on day 1 and continued to walk throughout the experiment. Radiographically there was good alignments which remained until the calf was euthanatized and necropsied. One pin was set too deeply into the distal fragment but did not cause any serious problems. The fracture gap was still evident on day 42 but healing was evident. Grossly, there was adequate reduction and healing by callus was occurring although solid union had not developed.

Calf No. 756 was fixed with 1-1/4" and 1-3/16" intramedullary pins[V] and placed in an Ehmer sling. The calf was up and walking on day 1. Radiographically there was a slight varus deviation of the fracture site and the pins could have been set deeper into the distal fragment. The 2-week radiograph revealed that the fracture had compacted. At 6 weeks there was a large periosteal reaction and there was union of the fracture ends, however it was not solid. Grossly, there was evidence of infection around the pins. Histopathological examination revealed a small abscess in the periosteum with fibrous tissue callus and cartilage. There was osteoid production and remodeling in the cortex and the internal callus showed regular bone, mature fibrous tissue, and a small sequestrum.

Calf No. 758 was repaired using 2-1/4" intramedullary pins[V] and no external fixation. He walked on the affected leg on day 1 but knuckled on the fetlock for 8 days postoperatively. Radiographically the pins did not fill the entire marrow cavity. At 2 weeks the pins had backed out approximately 1 cm and the fracture had compacted. There was considerable periosteal reaction by day 28 which continued to increase in size until

the end of the experiment. Histologically, there was evidence of movement of the fracture and inflammation. Healing was occurring.

Calf No. 757 was equipped with a Kirschner apparatus[u] and Thomas splint. The calf showed early ambulation and postoperative radiographs revealed adequate reduction. At 2 weeks postoperatively there was a suppurative material draining from tissue surrounding the pins and the pins had worked out of the proximal fragment. The fracture had broken down and was severely overriding. Histopathological exam revealed increased amount of fibrous tissue and an abscess at the fracture site. A diagnosis was made of osteomyelitis and non-union.

Calf No. 743 was equipped with a Kirschner apparatus[u] and Ehmer sling. This calf had difficulty ambulating and the calf showed a persistent fever despite various antibiotic treatments. At two weeks post surgery there was drainage from the pin sites and radiographically the fracture had broken down. The histopathological examination revealed dead and dying bone in cortex with a large abscess and liquifying necrosis. A diagnosis was made of osteomyelitis and non-union.

Calf No. 751 was equipped with a Kirschner apparatus[u] and no other fixation. Postoperatively the fracture was adequately reduced. The 2-week radiograph revealed that the fracture had broken down with no apposition of the fractured ends. Grossly, there was no healing occurring with an abscess at the end of the fracture. Histologically, there was excess callus, chronic inflammation, pockets of PMN's and the cortex was dead and dying. The marrow cavity showed an increased amount of fibrous tissue, and a diagnosis was made of osteomyelitis and non-union.

Calf No. 749 was repaired using a 7-hole standard ASIF broad plate[t] and 6 standard cortical screws.[t] A cerclage wire was placed in

the fracture site to stabilize a chip fracture that occurred while clamping the bone plate in place. The calf was placed in a modified Thomas splint. The 2-week radiograph revealed the distal 4 screws were loose and the plate pulled away from the distal fragment. At 4 weeks the radiograph revealed that all of the screws were loose and an increase in the amount of periosteal reaction. Histopathological findings were dead and dying cortex with irregular callus formation, increased fibrous tissue, and capillary formation. The marrow cavity was filled with fine immature connective tissue with no apparent internal callus. The diagnosis was made of healing fracture with malalignment.

Calf No. 738 was repaired using a 6-hole standard ASIF broad plate[t] and 6 cortical screws.[t] An Ehmer sling was placed on the calf to keep the leg in flexion. The calf was able to stand with assistance on day 1. Postoperative radiographs revealed a valgus deformity of the fracture and a wide fracture gap and the plate was not well contoured to the bone. The 2-week radiograph visualized the fracture in the relative same position except that the top screw appeared to be loose. The 4-week radiograph revealed that screws #3 and #4 were loose with an increase in the periosteal reaction and no change in alignment. The 6-week radiograph revealed all of the screws loose with no change in alignment. Grossly, the bone was healing although all of the screws were loose and the plate was no longer in contact with the bone. Histopathological examination revealed marked external callus, osteoid and bone formation with increased osteoblastic activity. The marrow cavity showed much internal callus with fine connective tissue. A diagnosis was made of healing fracture.

Calf No. 750 was repaired with a 6-hole standard ASIF broad plate[t] and 6 cortical screws.[t] This calf had no external fixation. The calf was up and walking on day 1. Two weeks later the radiographs showed that 5 of 6 screws were loose and the fracture was overriding with malalignment. At 4 weeks postoperatively the plate had pulled away from the bone. Histopathological examination showed a callus that was neither dense nor wide with a cellular make up. The cortex was normal bone but there were PMN's at the fracture site. The marrow cavity showed hemorrhage with increased numbers of macrophages and PMN's. The diagnosis was fracture, with osteomyelitis.

Discussion

This work supports to some extent the findings of previous reports.[3,5,7] Femoral fractures continue to present a problem and challenge to the practicing veterinarian when it occurs in large animals, young or old. Sepsis continues to be a complicating problem that faces the veterinarian despite the most vigorous attempts to control it. Another problem is rigid fixation of the fracture until healing occurs. There is no apparent deficiency in the healing mechanism of these calves if the bone can be held in such a position to allow healing to occur.

Calf No. 741 was chosen as a control with no internal fixation and only a Thomas splint to exemplify the type of fixation commonly used by the practicing veterinarian. This calf was never able to stand and died on day 12 of pneumonia with no sign of healing. Two other calves died prior to the conclusion of the experiment of pneumonia and/or enteritis. These calves exemplify the importance of the health of the calf and a clean environment for optimal healing. These calves died on day 12 and 3 postoperatively and showed no evidence of healing.

Three calves which had intramedullary pins placed in the fractured femur survived the duration of the project. All of them were healing with callus formation although one showed a slight amount of infection around the pin. All of these calves were able to ambulate on the affected leg at the time of euthanasia and all of the femurs were relatively well aligned with minimal overriding or deformity.

The success noted with the calves with intramedullary pins can be attributed to several factors. The multiple pins that were placed in the leg were able to adequately immobilize the fracture and allow healing. The pins stabilized the fracture and allowed it to compact. However, the best immobilization and healing occurred when the marrow cavity was completely filled with intermedullary pins. This is not likely to occur in other than a midshaft fracture of the femur in calves. The pins must also be driven deeply enough into the distal fragment as to not allow them to back out, yet not so far as to penetrate the articular cartilage of the stifle joint and interfere with locomotion. Infection may be a problem with intermedullary pins when the retrograde technique is employed and the pins are allowed to penetrate the intact skin, then driven back into the medullary cavity.

The calves with the Kirschner apparatus did not heal as well as the intramedullary pinned calves. The fractures had broken down in all three calves by two weeks postoperatively. The pins had loosened in the proximal fragment in all cases. Grossly there was severe overriding and malalignment with abscessation and infection at the fracture site. The body temperature remained elevated in this group of calves despite various antibiotic therapies. The Kirschner apparatuses were bent, broken, and served no useful purpose in the fixation of the femurs.

All of the fractures were termed non-unions with excess fibrous tissue at the conclusion of the project.

There were primarily two reasons for the failures seen in the calves with the Kirschners. The first was sepsis which apparently traveled down the pins and into the fracture area. The second was that the Kirschners were not able to immobilize the bone and allow healing. The pins that were placed transversely in the bone loosened primarily due to the thin cortex and the extreme muscle pull found in young calves. The external component of the Kirschner was at a distinct mechanical disadvantage due to the muscle mass of the hind limb of the calf.

The three calves with bone plates healed better than the calves with the Kirschner apparatus but not as well as the calves with intramedullary pins. Practically all of the screws of every plate had loosened and allowed movement of the fracture to some extent. There was overriding of the fractures in 2 of the 3 calves with excess fibrous tissue around the fracture. The calves with plates did not show the amount of infection of the Kirschner apparatus calves although there was infection in the fracture site of one of the plated calves. The final diagnosis in the calves with plates was healing fracture with overriding and rotational malalignment.

The major problem encountered when using bone plates and screws was that the thin cortex did not allow the screws to become securely seated into the bone, thus allowing the screws to loosen and the fracture to break down. This problem could possibly be aleviated by using cancellous screws or bolts with taps rather than standard cortical screws.

This experiment was also an attempt to determine the affects of different types of postoperative care. Therefore, 4 calves were fitted

with an Ehmer sling, 4 with a modified Thomas splint, and 4 with no external fixation.

Generally, the calves with the modified Thomas splint and those with no external fixation were able to stand and ambulate much sooner and easier than those with the Ehmer sling. It was also noted that the calves that were the most active returned to normal temperature and appetite earlier than those calves with difficulty standing and walking. There was little effect on the healing of the bone when comparing the external fixation except that the Calf No. 738 with the bone plate and Ehmer sling was healing with less malalignment than those calves with plates which could bear weight on the affected leg.

Summary

Twelve Holstein calves had their right femur fractured and repaired with intramedullary pins, Kirschner apparatus, or bone plates and screws. Nine calves survived the 6-week experiment. Three of the nine were equipped with modified Thomas splints, three with Ehmer slings, and three with no external fixation.

The three calves with intramedullary pins were all healing with little malalignment or overriding. When euthanatized the three calves with Kirschner devices were considered non-unions with severe overriding, malalignment and osteomyelitis. The three calves with bone plates and screws were healing although the screws had loosened and allowed overriding with rotational malalignment of the fractures.

The calves equipped with the Thomas splints and those with no external fixation were able to stand and ambulate much quicker and with less difficulty than the calves with the leg placed in an Ehmer sling.

TABLE OF RESULTS

Calf I.D.	Type of Internal Fixation	Type of External Fixation	Final Results
741	None	Modified Thomas splint	Died; day 12; Pneumonia
744	Intramedullary pins	None	Died; day 12; Pneumonia
740	Intramedullary pins	Ehmer sling	Died; day 3; Pneumonia enteritis
736	Intramedullary pins	Modified Thomas splint	Healing
756	Intramedullary pins	Ehmer sling	Healing osteomyelitis
758	Intramedullary pins	None	Healing
757	Kirschner apparatus	Modified Thomas splint	Osteomyelitis; Non-union
743	Kirschner apparatus	Ehmer sling	Osteomyelitis; Non-union
751	Kirschner apparatus	None	Osteomyelitis; Non-union
749	Bone plate	Modified Thomas splint	Healing; Malalignment
738	Bone plate	Ehmer sling	Healing
750	Bone plate	None	Osteomyelitis; Malalignment

Experiment terminated on day 42 post surgery.

Calf 741: No internal fixation with a modified Thomas splint.

Fig. 1 & 2: Fracture 12 days post surgery. There is no healing of the fracture. (Note the free floating chip found on necropsy examination.)

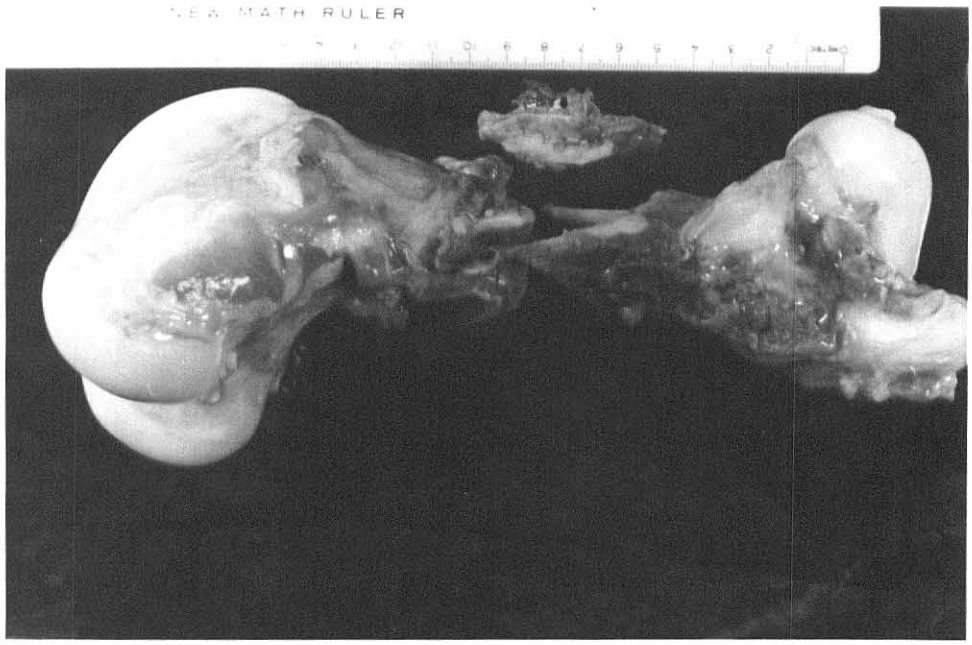

Fig. 1

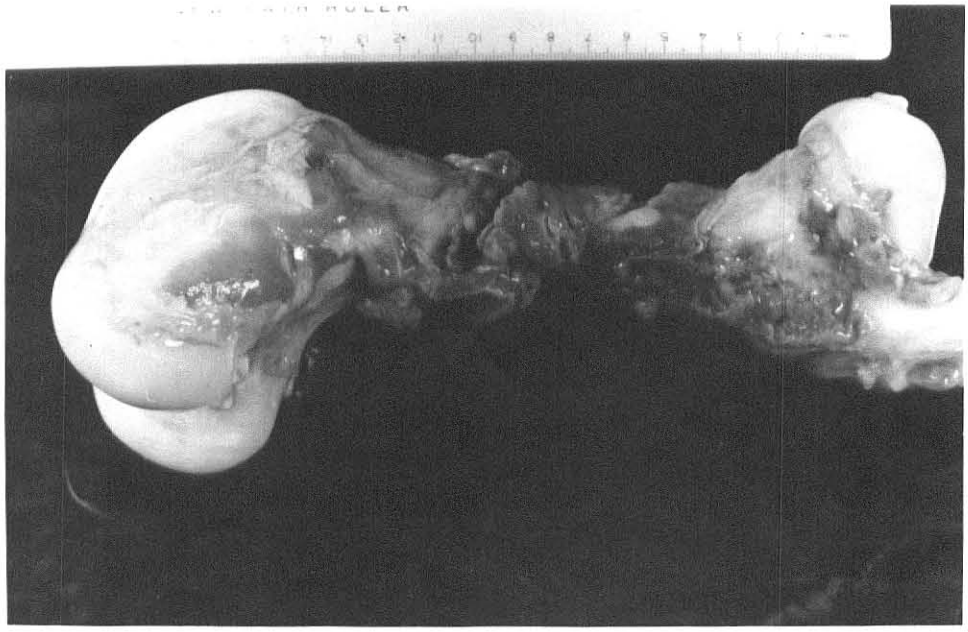

Fig. 2

Calf 744: Intramedullary pins with no external fixation.

Fig. 3: Fracture 12 days post surgery. There is no evidence of healing.

Fig. 4: Sagittal section of the femur 12 days post surgery.

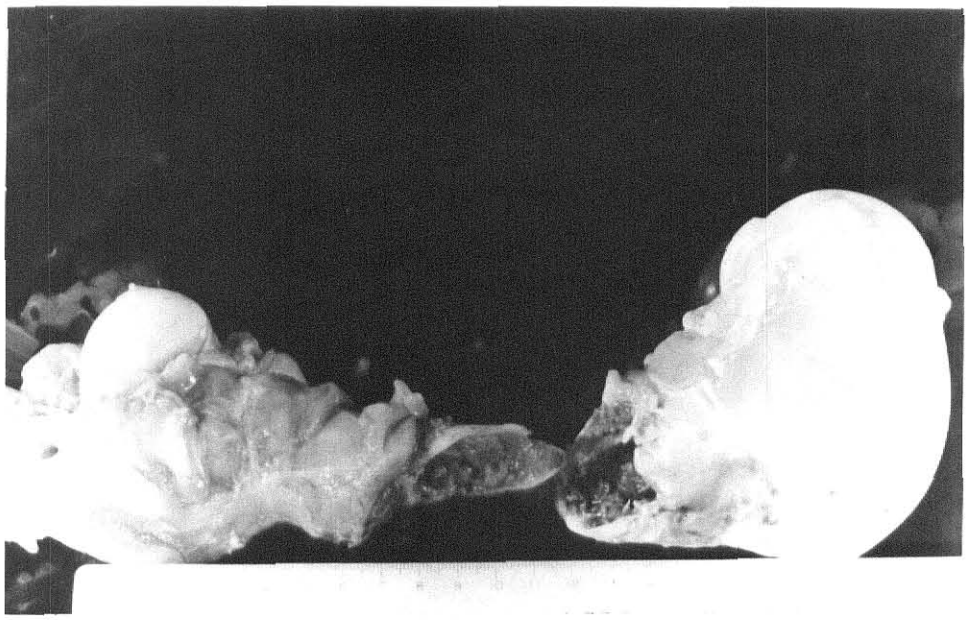

Fig. 3

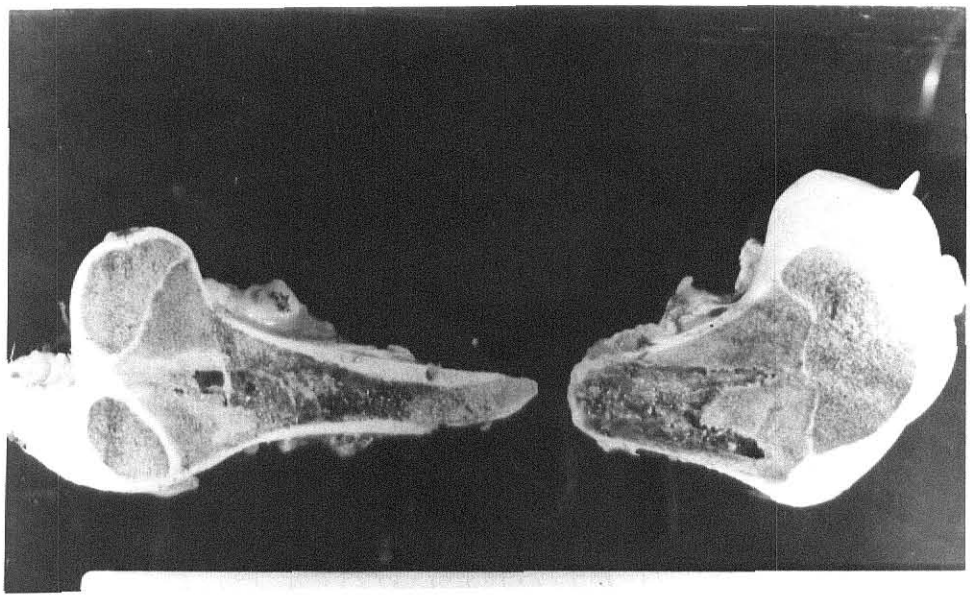

Fig. 4

Calf 736: Intramedullary pins with a modified Thomas splint.

Fig. 5: Marked healing by callus formation 42 days post surgery.

Fig. 5

Calf 756: Intramedullary pins with an Ehmer sling.

Fig. 6: Sagittal section of femur with infection around the pin tracts.

Fig. 7: Healing fracture by callus formation 42 days post surgery.

Fig. 8: Photomicrograph of external callus with cartilage, H & E (250 x).

Fig. 9: External callus with increased amount of fibrous tissue, H & E (250 x).

Fig. 7

Fig. 9

Fig. 6

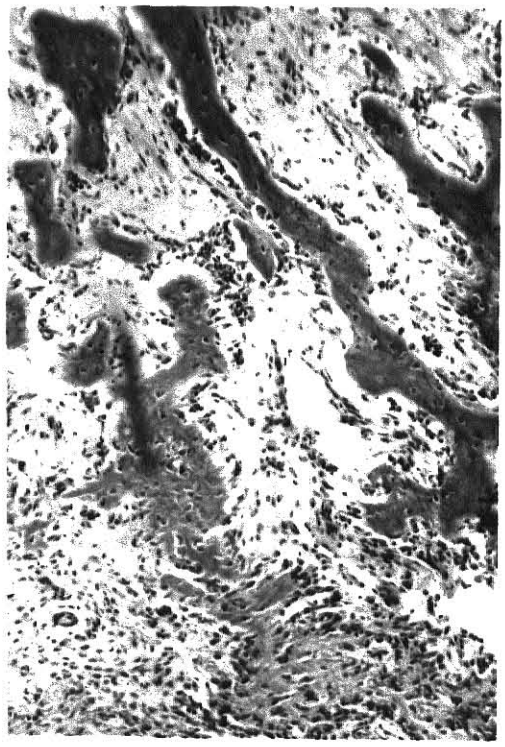

Fig. 8

Calf 758: Intramedullary pins with no external fixation.

Fig. 10: Sagittal section of femur with pins intact.

Fig. 11: Healing of fracture by callus formation.

Fig. 12: Fibrous tissue and cartilage around the fracture site, H & E (250 x).

Fig. 13: The marrow cavity with hyaline cartilage, callus, immature connective tissue and hemorrhage, H & E (250 x).

Fig. 11

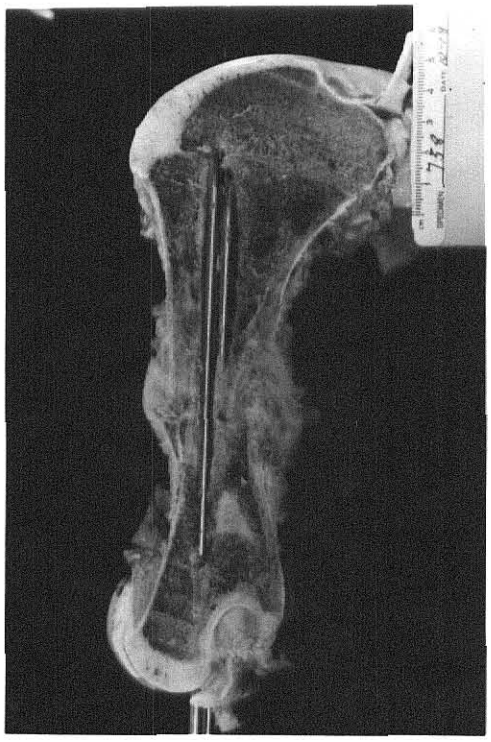

Fig. 10

Fig. 13

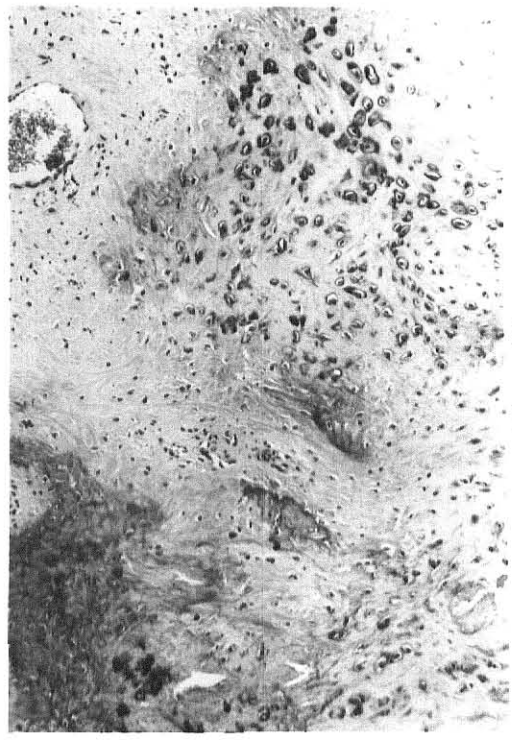

Fig. 12

Calf 757: Kirschner device with modified Thomas splint.

Fig. 14: Sagittal section of femur showing overriding and fibrous tissue reaction. (Note the gelatinous area of bone necrosis at the point of pin penetration in distal marrow cavity.

Fig. 15: Fractured femur showing overriding and large fibrous reaction over the proximal fragment.

Fig. 16: External callus, H & E (250 x).

Fig. 17: External callus with osteomyelitis, H & E (250 x).

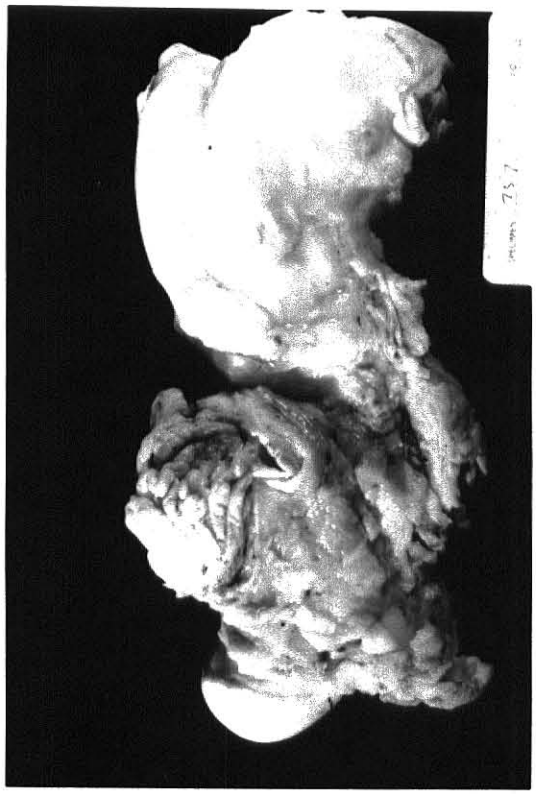

Fig. 15

Fig. 14

Fig. 17

Fig. 16

Calf 743: Kirschner device with an Ehmer sling.

Fig. 18: Sagittal section of femur with non-union.

Fig. 19: Fractured femur with overriding, fibrous tissue and devitalized bone.

Fig. 20: Marrow cavity with abscess, H & E (250 x).

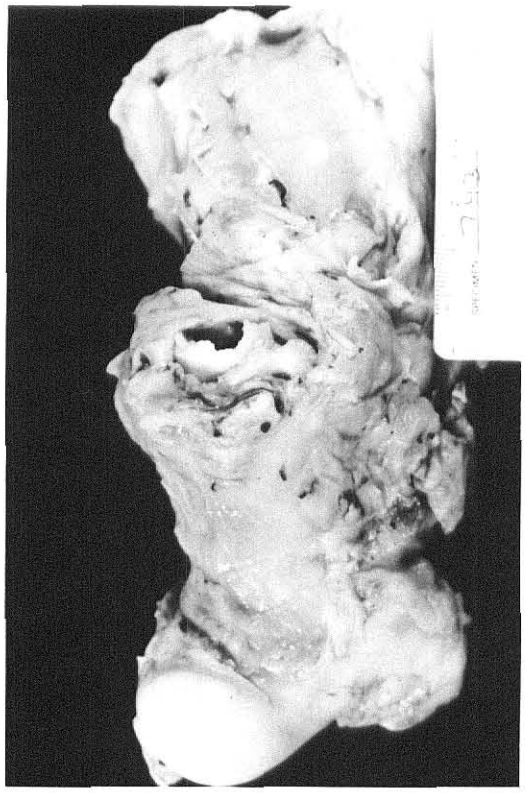

Fig. 19

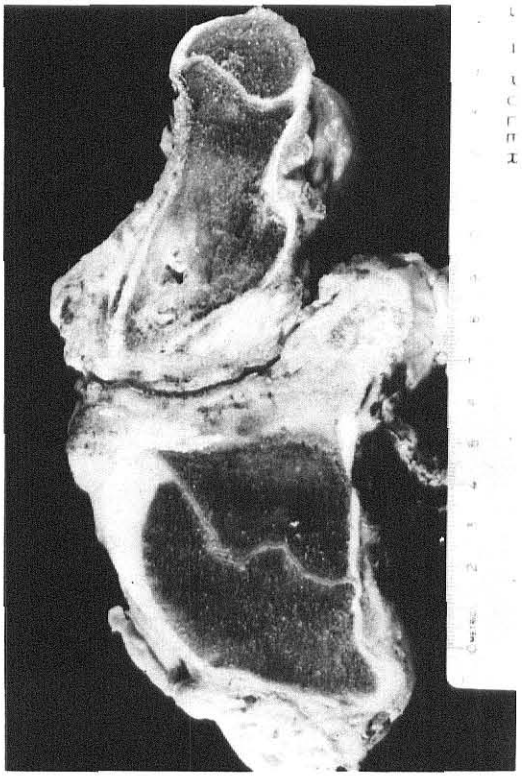

Fig. 18

Fig. 20

Calf 751: Kirschner device and no external fixation.

Fig. 21: Fractured femur with large fibrous tissue reaction, thick-walled abscess, and overriding.

Fig. 22: Sagittal section of fractured femur with necrosis around pin sites, abscess, fibrous tissue reaction.

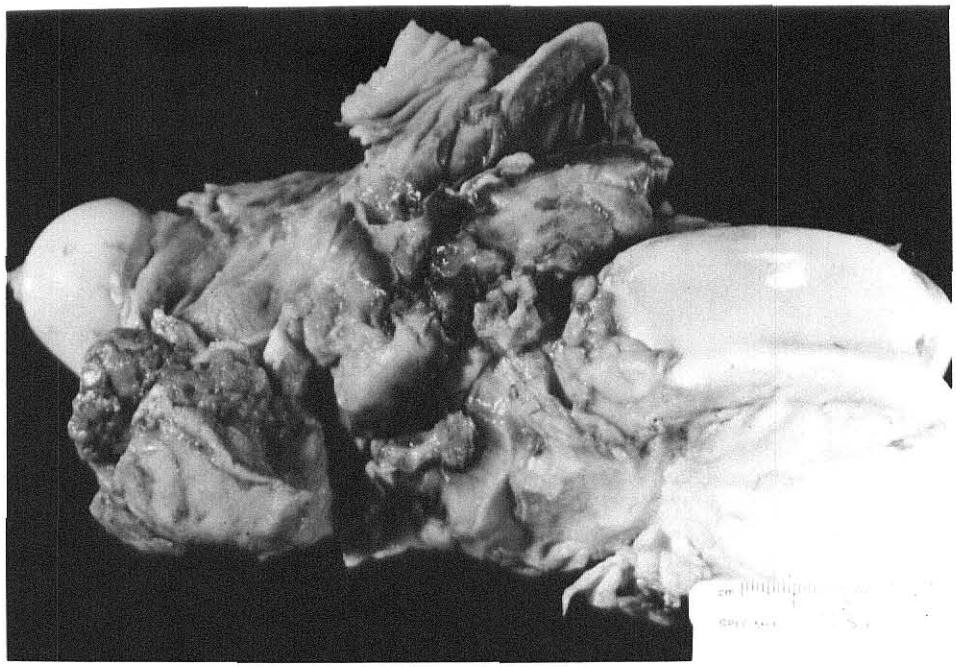

Fig. 21

Fig. 22

Calf 749: Bone plate with modified Thomas splint.

Fig. 23: Marrow cavity with fine immature connective tissue, H & E (250 x).

Fig. 24: Fragmented external callus, H & E (250 x).

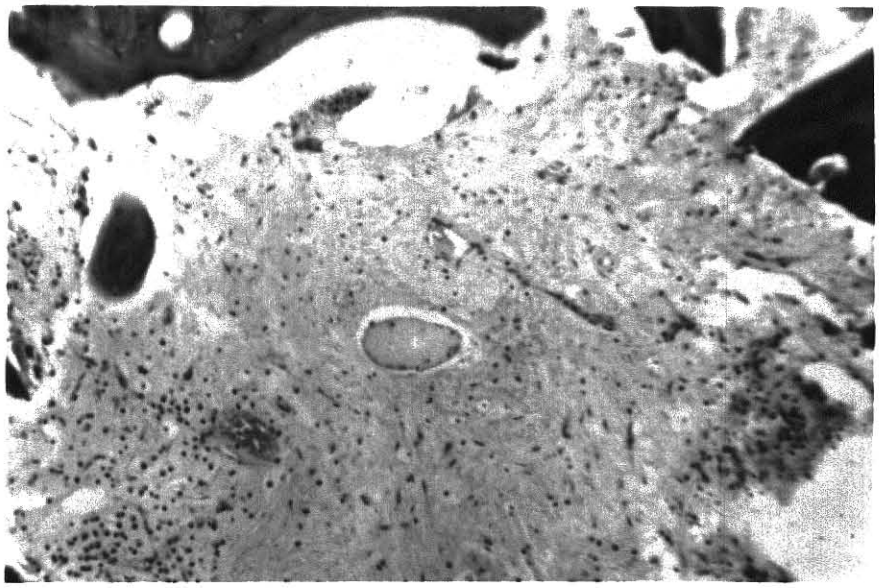

Fig. 23

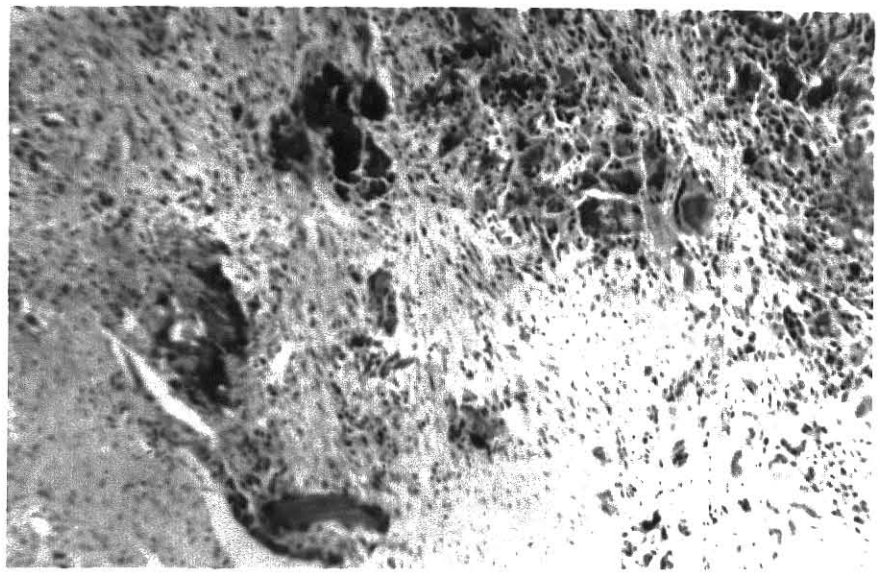

Fig. 24

Calf 738: Bone plate with an Ehmer sling.

Fig. 25: Sagittal section of fractured femur with healing by callus formation. (Note the gelatinous necrosis around the screw holes.)

Fig. 26: Fractured femur with bone plate intact. (Note the screws have backed out of the plate.)

Fig. 27: Marrow cavity with internal callus and bone spicules partly covered with osteoblasts, H & E (250 x).

Fig. 28: Marrow cavity with fine immature connective tissue, H & E (250 x).

Fig. 26

Fig. 25

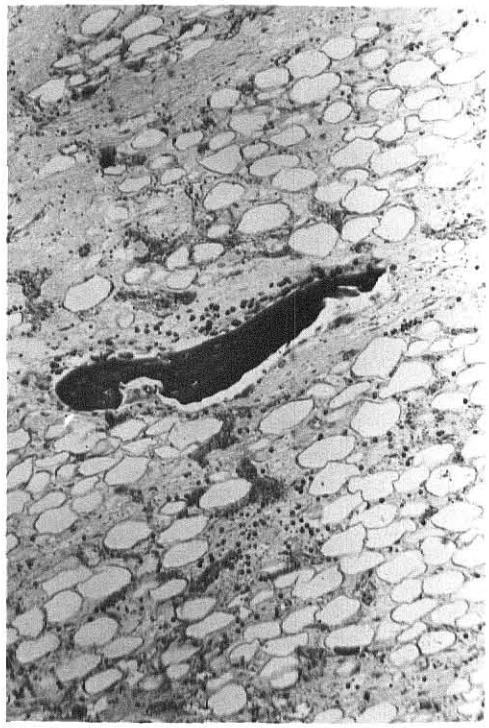

Fig. 28

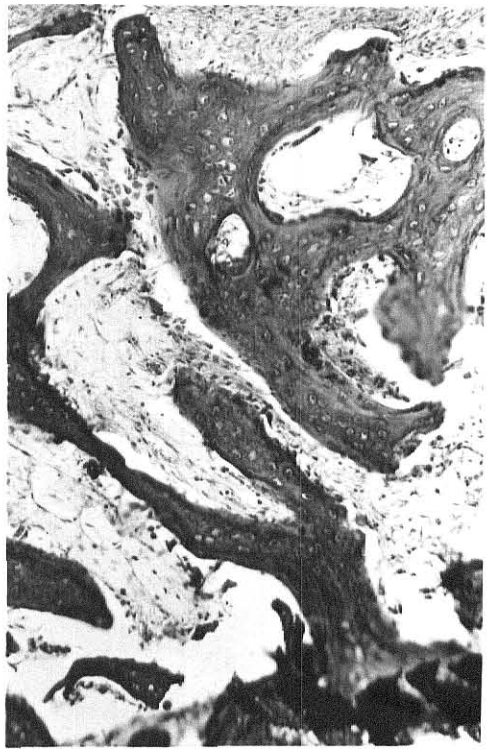

Fig. 27

Calf 750: Bone plate with no external fixation.

Fig. 29: External callus with fine connective tissue, H & E (250 x).

Fig. 30: Marrow cavity with hemorrhage and osteomyelitis, H & E (250 x).

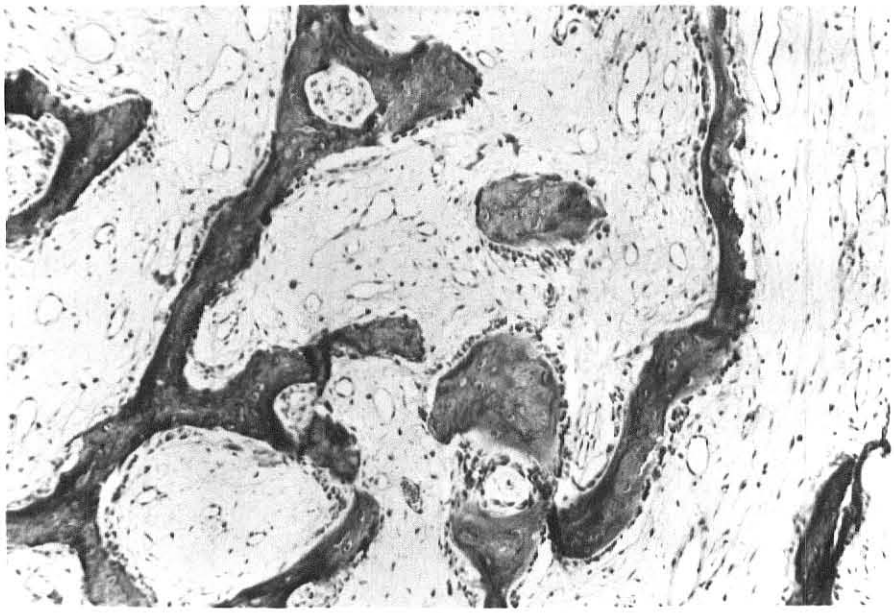

Fig. 29

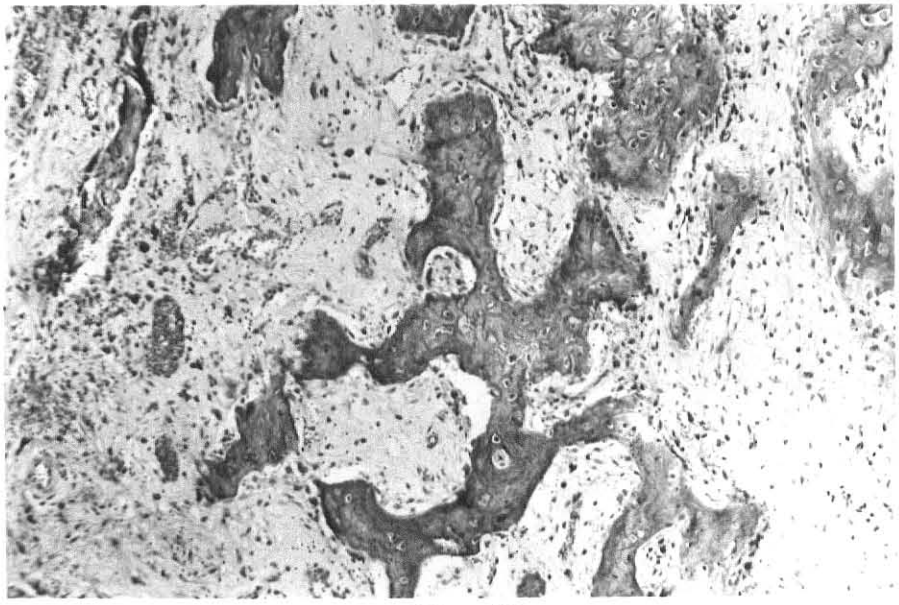

Fig. 30

REVIEW OF THE LITERATURE

A text concerning cattle lameness states that attempts of fracture repair of long bones is disappointing unless speaking of the young calf.[4] Metacarpal, metatarsal, radius and tibial fractures aleviate themselves to fixation with internal and external methods. The biggest problem encountered in a study of 15 of 25 successful cases of lower leg fractures was sepsis.[3] Plaster casts and short Thomas splints were used to fix metacarpal and metatarsal fractures in cattle in India,[9] while cross-pinning has also been employed as a technique of tibial fracture fixation in cattle.[10]

All of the techniques mentioned have reasonable successes when applied to the lower limb. The femur presents some special problems. The anatomical position of the femur does not lend itself to casting and the splinting technique is not an adequate method of fixation. The large muscle mass surrounding the bovine femur prohibits practically all external fixation devices commonly used in orthopedics. It has been stated that intramedullary pins work the best and that the Kirschner apparatus and Thomas splints do not work well on the bovine femur.[5]

In a photo essay, the fixation of a fractured femur in a young calf with intramedullary pins was successful.[1] One author reported the use of intramedullary pins in the fixation of a 6-week-old calf and the use of 6-hole bone plate on a calf 1 week old.[11] There was good healing in the pinned calf. While the calf with the bone plate healed, there were a few complications. One screw broke, the plate was straightened, and a chip fracture developed.

It was also reported that 4 of 6 experimental cases of fractured femurs showed good healing with intramedullary pinning while 1 developed osteomyelitis and 1 had a hip dislocation. Two calves with only a Thomas splint had overriding of the fracture and lameness. One calf with a bone plate and a Thomas splint was lame. Six clinical cases of fractured femur was also reported. One older cow and a calf with a Kirschner apparatus died while the calves with intramedullary pins healed and a calf with a Thomas splint had overriding of the fracture.[7]

MATERIALS AND METHODS

Twelve Holstein bull calves were purchased from a western Kansas dairy. They ranged in age from 1-7 days, 80-100 pounds. The calves were given a physical examination to determine their state of health. The physical examination included temperature, pulse, respiration, evaluation of the fecal character and a blood test including complete blood count, total protein, serum dehydrogenase, chloride, sodium, potassium, carbon dioxide, blood urea nitrogen, alkaline phosphatase, albumin, calcium, inorganic phosphorus, glucose, and creatinine.

All of the calves received 30 ml of Serogen L.A.[a] subcutaneously, 5 ml of Multibex C[b] IM, and if the feces appeared loose, a Panmycin[c] or Enterfur[d] bolus orally.

The calves were checked daily and were given 5 ml of Multibex C[b] IM for 4 days. Daily evaluation of the fecal character, temperature, and general appearance determined the administration of Panmycin[c] or Enterfur[d] orally.

The calves were housed in small stalls with 2-3 calves per stall. The stalls did not have bedding but were washed out daily. The diet consisted of milk replacer[e] fed via nipple bucket twice daily. The calves were kept in this area until normal fecal character, normal appetite, and normal temperature were observed.

The calves were then moved to Dykstra Veterinary Hospital for surgery. They were housed in straw bedded free stalls (5-6 calves

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[d]Enterfur, Eaton Veterinary Laboratories, Division of Norwich Products Inc., Norwich, NY 13815

per stall) which were cleaned daily. Milk replacer[e] was fed twice daily to the calves for the remainder of the experiment. Omolene[f] and prairie hay were given free choice to supplement the milk replacer.

Surgical Procedure

The calves were not fed on the day of surgery. The right rear leg was clipped on the lateral aspect with a #40 clipper head. Atropine sulfate[g] was given as a preanesthetic agent subcutaneously at the rate of .02 mg/lb. Anesthesia was induced with thiamylal sodium[h] IV to affect. The dosage varied but approximated 3 mg/lb. The calves were intubated and were connected to an anesthetic machine with a mixture of Halothane[i] and oxygen to maintain anesthesia.

The calves were placed in left lateral recumbency. The right rear leg was prepared for surgery with Septodyne scrub[w] and Septodyde[x] surgical antiseptic.

The calves were completely draped and the surgeons wore caps, masks, gowns and two pair of surgical gloves to protect the calves from accidental puncturing of the gloves while minipulating the bone.

A skin incision was made starting over the greater trochanter, extending along the shaft of the femur, to the femoral-tibial joint. Hemorrhage was controlled with forci-pressure and ligation. The subcutaneous tissue was separated to expose the fascial plane between the tensor fascia lata and the biceps femorus muscle which was incised. A periosteal elevator was used to remove the attachment of the vastus lateralis muscle and expose the shaft of the femur.

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[f] Omolene, Ralston Purina Co., St. Louis, MO 63188

The femur was fractured by drilling 4 holes transversely through the bone in the midshaft area to weaken the bone at that point. A 3/16" Steinman pin[v] and a hand chuck or Stryker[s] drill was used to drill the holes. The fracture was produced by placing the edge of a Bard Parker handle over the weakened area of the bone and rapping it with a mallet. The bone was manipulated to distract the fracture ends and then repaired using one of three techniques.

The fracture was repaired with open reduction by 1) intramedullary pins[v] in a retrograde technique, 2) Kirschner apparatus,[u] and 3) bone plates and screws.[t] One calf of each internal technique was fitted with a modified Thomas splint to keep the leg in extension. One calf of each internal technique had the affected leg placed in an Ehmer sling to keep the leg in flexion, and one calf of each internal fixation technique had no external immobilization placed on the leg. One calf served as a control and had no internal fixation and was fitted with a modified Thomas splint.

The incision site was flushed with 1 million units of potassium penicillin.[j] The muscle layers were closed with #1 medium chromic catgut[k] with a swedged atraumatic needle in a simple continuous pattern. The subcutaneous tissue was closed in a similar manner. The skin was closed with heavy Vetafil[l] in a continuous interlocking pattern.

All of the calves were connected to a continuous intravenous drip of lactated ringers solution[r] throughout the procedure.

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[s]Stryker, Stryker Corp., Kalamazoo, MI 49001

Postoperative

The calves were started on antibiotics postoperatively. They were observed daily and evaluated by temperature, appetite, locomotion, and visualization of the incision site. The skin sutures were removed in 10 days to 2 weeks.

Radiographs were taken postoperatively, on day 14, day 28, and day 42. The radiographs consisted of a lateral and anterior posterior view of the affected leg.

The calves were photographed on day 42 and euthanatized with saturated $MgSO_4$ solution IV. An immediate necropsy was performed. The involved femur was removed and photographed. A sagittal section of each femur was done and the bone rephotographed. A section of the fracture site was decalcified, sectioned, mounted, and stained with hematoxalin and eosin. The histopathological slides were read and photographed to record the findings.

RESULTS

Calf Number 741

A Holstein bull calf approximately 3 weeks of age and 110 pounds was anesthetized. The right rear leg was prepared for surgery. The right femur was fractured and distracted as described. This calf was intended to be a control. There was no internal fixation placed in the femur. The area was bathed in 1 million units of potassium penicillin[j] and routinely closed. A modified Thomas splint was placed on the leg. Due to time discrepancies, the postoperative radiographs were not taken until day 1.

The postoperative radiographs revealed a transverse mid-shaft fracture. The fragments were not in apposition and were overriding with the proximal fragment lying anterior dorsal of the distal fragment by 3 cm.

The calf attempted to rise on day 1 but could not stand. Erythromycin[m] therapy was initiated at the rate of 1.25 ml I.M. b.i.d., A moist cough was noted. The calf continued to eat well but developed a yellow pasty fecal material on day 3. The calf's temperature was subnormal on day 6 and the calf was shivering. The pasty feces remained and the calf remained recumbent although the appetite was good. The calf was very depressed on day 10 and 11 and was found dead on day 12. A necropsy was performed the same day.

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[m]Erythromycin, Abbott Laboratories, North Chicago, IL 60064

Grossly, there was enteritis and pneumonia. The fracture showed no evidence of healing and there was a large bone fragment free-floating from the proximal femur. There was no histopathology done on this calf.

Calf Number 744

A Holstein bull calf approximately 2 weeks of age was anesthetized and the right rear femur was prepared for surgery. The right femur was fractured as described and repaired by inserting 2-1/4" intramedullary Steinman pins[v] into the proximal fragment using the retrograde technique. The fracture was reduced and the pins seated into the distal fragment with a mallet and punch. The area was bathed in 1 million units of potassium penicillin[j] in saline and routinely closed.

The fracture in this case was not transverse as anticipated, but was oblique. There was overriding of the fracture ends, and the pins were driven through the anterior distal end of the distal fragment. Postoperative radiographs also revealed that the pins did not totally fill the medullary cavity. There was no external fixation placed on the calf's leg.

Antibiotic therapy with 500 mg Ampicillin[q] I.M. was begun on day 1. The calf was alert, ate well, and had a normal temperature. The calf could not stand and grew steadily weaker despite a good appetite and antibiotic treatment. On day 9 the temperature rose to 104.2°F and the calf was more depressed. The calf was given 1 gm of sulfadimethoxine[y] orally, which brought the temperature to within normal limits. The calf appeared alert and ate on day 11, although he was still down and

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[q]Ampicillin, Bristol Laboratories, Div. of Bristol Myers Co., Syracuse, NY 13201

[y]Albon, Hoffman Roche Inc., Nutley, NJ 07110

refused to stand with assistance. He was found dead on day 12 at 7:30 AM. A necropsy was performed the same day.

Grossly, there was pneumonia involving both lungs. The fracture showed no sign of healing. The pins and fracture showed no substantial change from that described in the postoperative radiograph.

Microscopically, the lungs revealed purulent bronchopneumonia. The femur cortex revealed recent fracture and a fracture fragment with dead and dying bone. There was very little callus formation, and the bone marrow showed hemorrhage and fracture fragments.

Calf Number 740

A Holstein bull calf approximately 2 weeks of age was anesthetized, and the right rear leg was prepared for surgery.

The femur was fractured as per schedule and repaired with 1-1/4" and 1-3/16" intramedullary Steinman pins[v] using the retrograde technique. The pins were placed into the distal fragment using a mallet and punch. The area was bathed in 1 million units of penicillin[j] in saline and closed routinely.

The calf's leg was placed in flexion by means of an Ehmer sling. Postoperative radiographs were taken and revealed a mid-shaft transverse fracture of the femur. The 2 Steinman pins[v] used for fixation should have been set deeper into the distal fragment. The reduction was adequate and alignment satisfactory. The pins did not fill the medullary cavity in the distal fragment.

The calf was given 500 mg Ampicillin[q] I.M. s.i.d. and stood with help, although he could not support his full weight on the left rear leg.

The second day the calf was less active and would not attempt to get up.

The third day the calf was dehydrated and died at 8:30 AM. A necropsy was performed the same day. The femur showed no evidence of healing and the calf was diagnosed as enteritis and pneumonia with pasteurella multocida isolated from the lungs.

Calf Number 736

A Holstein bull calf 2 weeks of age was anesthetized and the right rear leg prepared for surgery. The right femur was fractured as described and repaired by inserting 3 intramedullary Steinman pins[v] (2-1/4" and 1-3/16") in a retrograde fashion into the proximal fragment. The fracture was reduced and the pins driven into the distal fragment with a mallet and punch. The area was bathed in 1 million units of Potassium penicillin[j] and closed routinely.

A modified Thomas splint was made from 1/2" aluminum rod to fit the leg and keep the leg in extension.

Postoperative radiographs were taken, and it was determined that the femur was fractured transversely in the mid-diaphyseal region. The reduction and alignment was adequate, but 1 of the 3 pins had been driven too deeply into the distal fragment and had gone through the articular cartilage of the femur. Anterior posterior radiographs revealed that the pins had filled the marrow cavity; however, the lateral view indicated that distal fragment had not been filled.

The day after surgery the calf could stand with assistance and would bear weight on the affected leg. He was kept on 500 mg Ampicillin[q] I.M. s.i.d. for 5 days postoperatively.

Two weeks following surgery radiographs revealed periosteal reaction around the fracture site and no position change in the pins. The calf continued to bear weight and walk on the affected limb through-

out the experimental period. Four-week radiographs indicated a large periosteal reaction and callus around the fracture ends. The fracture gap was still present at that time. The 6-week radiographs showed a large callus surrounding the bone, although the fracture was not healed and the fracture could still be seen. The calf was euthanatized with $MgSO_4$, and a necropsy was performed. The femur had a solid union. Although healing was not complete, the pins were in the original location. Photographs were taken of the bone.

Calf Number 756

A Holstein bull calf approximately 110 pounds was anesthetized and the right rear leg prepared for surgery.

The femur was fractured as described and repaired with 1-1/4" and 1-3/16" intramedullary Steinman pins[v] using the retrograde technique to place the pins into the proximal fragment. The fracture was reduced and the pins were seated into the distal fragment using a mallet and punch. The area was bathed in 1 million units of potassium penicillin[j] in saline and routinely closed.

Postoperative radiographs were taken, and the leg was placed in an Ehmer sling to keep it in flexion.

The radiographs revealed a midshaft transverse fracture of the femur. The lateral view revealed adequate reduction although the pins did not fill the medullary cavity. The anterior posterior view indicated a varus deformity of the fracture site.

The first day postoperatively the calf was standing and walking on the affected leg. Erythromycin[m] was given at the rate of 1.25 ml I.M. b.i.d.

On day 3 there was drainage at the penetration site of the pins. Despite local treatment, a seroma formed over the proximal end of the pins. The seroma began decreasing in size on day 10 and became static on day 12.

On day 13 there was evidence of reddening along the incision line, and the temperature was 104°. Procaine Penicillin G[z] was administered at the rate of 2 1/2 ml I.M. b.i.d., and the infection was brought under control. Urine scald developed around the sheath due to the urine retention in the wet Ehmer sling.

Radiographs taken at 2 and 4 weeks revealed callus formation with no change in the deformity. The fracture appeared to have compacted.

A 6-week radiograph revealed much periosteal activity around the fracture and callus formation. The fracture gap was still present and the fracture had not healed. The calf was euthanatized with $MgSO_4$ and a necropsy performed.

Grossly, there was a very large callus around the fracture site. The fracture had compacted at some time during the experimental period. There was a union, but it was not solid. Microscopically, the periosteum revealed fibrous tissue, callus and cartilage. There were islands of cartilage in irregular callus, and one small abscess was noted. The cortex was healthy and alive with osteoid being layed down and remodeling occurring. The marrow cavity had callus, bone and mature fibrous tissue, and one small sequestrum was noted.

Calf Number 758

A Holstein bull calf approximately 2 weeks of age and 110 pounds body weight was anesthetized and the right rear leg prepared for surgery.

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[z]Procaine Penicillin G. Pfizer Inc., New York, NY 10017

The femur was fractured as described and repaired with 2-1/4" intramedullary Steinman pins[v] using the retrograde technique to place the pins into the proximal fragment. The fracture was reduced and the pins driven into the distal fragment using a mallet and punch. The area was bathed in 1 million units of potassium penicillin[j] and closed routinely.

No external fixation was placed on the calf's leg and postoperative radiographs were taken. The radiographs revealed a mid-shaft transverse fracture of the femur. The pins did not completely fill the marrow cavity; however, they were placed correctly as to the distance (depth) inserted. The proximal fragment was displaced approximately 1/2 cm caudally as related to the distal fragment.

On the first day following surgery the calf could stand but was reluctant to move. Erythromycin[m] was given at the rate of 1.25 ml b.i.d. I.M.

On the third day postoperatively the calf would walk on the leg, but it was noted that he would knuckle over on the right rear fetlock. This knuckling persisted for 10 days before it corrected without treatment. The calf was kept on antibiotics to combat a persistent temperature rise and mild diarrhea. These were both controlled, and the calf was taken off Erythromycin[m] 18 days postoperatively.

Radiographs taken at 2 and 4 weeks postoperatively revealed a developing callus and that the pins had backed out approximately 1 cm. The fracture site had compacted and the fracture gap was still present.

Six weeks postoperatively radiographs revealed a large periosteal reaction and callus with the fracture gap still present. The calf was euthanatized with $MgSO_4$, and a necropsy was performed.

Grossly, the bone had a large callus around the fracture site. This was not solid, but healing was occurring. Histopath sections revealed evidence of movement at the fracture site. The periosteum revealed increased callus, fibrous tissue and capillaries. There were inflammatory cells present with bone spicules and micro fractures. The cortex revealed dead, dying bone and evidence of irregular hyline cartilage formation. The marrow cavity showed hyline cartilage and callus along with immature connective tissue and capillaries.

Calf Number 757

A Holstein bull calf approximately 3 weeks of age, 110 pounds, was anesthetized and the right rear leg prepared for surgery. The right femur was fractured as described and repaired using a Kirschner apparatus.[u] Two pins were placed in the proximal and distal bone fragments. When the fracture was reduced the pins were secured externally with a steel bar and clamps. The area was bathed in 1 million units of potassium penicillin,[j] in saline, and routinely closed. Postoperative radiographs were taken and a modified Thomas splint was placed on the leg to keep it in extension.

The postoperative radiographs revealed a transverse midshaft fracture. The fixation was less than desirable. Two transverse pins were well seated into the bone but there was an anterior deviation of the fracture site. This angulation of the fracture was approximately 120°.

The calf was begun on 1.25 ml Erythromycin[m] I.M. b.i.d. on day 1 and was standing the morning after surgery. On day 2 the calf could stand by himself. The calf spent most of the time lying down, but would get up to eat. It was noted that the calf was dragging the affected leg rather

than walking on it on day 6. By day 10 the calf's temperature had climbed to 104°F, his feces were pasty, and he had developed a cough.

Radiographs were taken on day 14 and exudate was exuding from around the pins of the Kirschner apparatus.[u] The radiographs revealed that the pins in the proximal fragment were pulled out and that the bones were no longer in apposition. The bone ends were mottled in appearance with probable osteomyelitis.

The calf continued to eat well despite the temperature of 103.4° to 104.5° and the exudate draining from the pin holes of the Kirschner apparatus.[u]

Radiographs were taken on day 28. A large mass of periosteal reaction was seen at the fracture site. The pins were pulled out of the bone, and the bone had lytic areas. There was no fixation of the fragment, and the fracture was not reduced.

There was no particular change in the next two weeks. The calf would ambulate and eat well. The temperature ranged from 101°F to 103.6°F. He was kept on penicillin-dihydrostreptomycin[o] 4 ml I.M. s.i.d. therapy throughout the remainder of the experiment.

The final radiographs were taken 6 weeks postoperative and the calf was euthanatized with $MgSO_4$. A necropsy was performed the same day.

The final radiographs revealed bone lysis and lytic areas around the pins of the Kirschner apparatus.[u] There was callus formation with increased periosteal activity. There was evidence of osteomyelitis.

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[o]Combiotic, Pfizer & Co. Inc., New York, NY 10017

Grossly, the necropsy revealed a large mass of fibrous tissue around the fracture site. There was malalignment of the bone and evidence of bone necrosis around the pin sites on sagittal section.

Microscopically, the periosteum had callus formation with increased fibrous tissue. There was infection with osteomyelitis and abscess in the periosteum. The cortex was healthy with no change from normal bone. The marrow showed connective tissue and fibroblasts with increased number of capillaries. There was irregularly arranged callus formation with osteomyelitis and abscesses, with no hemopoietic activity. The final diagnosis was fracture, osteomyelitis, and non-union.

Calf Number 743

A 4-week-old Holstein calf approximately 130 pounds was anesthetized. The right rear leg was prepared for surgery. The right femur was fractured as per schedule and repaired. The fixation was achieved by the use of a Kirschner apparatus.[u] Two pins were placed transversely in the proximal and distal fragments. After reduction of the fracture the pins were held in place with an external bar. The area was bathed in 1 million units of potassium penicillin[j] in saline and routinely closed. Postoperative radiographs were taken and the leg placed in an Ehmer sling.

The postoperative radiographs revealed a midshaft transverse fracture. The reduction and alignment of the femur was adequate. A defect at the fracture end, possibly due to missing bone, was observed.

On day 1 the calf could stand and move around the stall on 3 legs. He ate well and was started on Erythromycin[m] 1.25 ml I.M. b.i.d. His temperature was 103.2°.

The temperature rose to 104.5° on day 8. Despite antibiotic therapy, the temperature ranged from 102.4° to 105.2° throughout the

experimental period. The calf remained bright, alert, able to move around the stall, and had a good appetite although the temperature remained elevated.

Purulent exudate was found around the pins of the Kirschner apparatus[u] on day 14.

Radiographs were taken on day 15 and revealed that the fixation had broken down. The pins in the proximal fragment were completely out of the bone while one pin in the distal fragment was bent and the other had slipped. The fragments were at right angles to each other as viewed from the lateral side. There was a small amount of periosteal activity at the bone ends.

The Kirschner apparatus[u] was found to be broken on day 18. An attempt was made to re-align and repair the damage.

The Kirschner apparatus[u] was found to be very loose on day 22 and was found in the stall on day 23. There was much exudate exuding from the pin holes which were treated with H_2O_2 and potassium penicillin[j] topically. The wound continued to drain throughout the remainder of the experiment. The calf was changed to oxytetracycline[p] 300 mg I.M. s.i.d. as well as local treatment of the draining tracts with Furacin.[aa]

The calf was radiographed at 4 weeks postoperatively. The entire Kirschner apparatus[u] was gone. There was no internal fixation. There was slight periosteal reaction at the bone ends and the bones appeared very mottled. There was sclerotic bone and evidence of osteomyelitis.

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[p]Liquamycin, Pfizer & Co. Inc., New York, NY 10017

[aa]Furacin, Eaton Laboratories, Div. of Norwich Products Inc., Norwich, NY 13815

The calf showed little change or improvement until 6 weeks post-operatively when radiographs were taken and the calf was euthanatized with $MgSO_4$. The 6-week radiographs showed much sclerotic bone with osteomyelitis. There was no internal fixation, no stabilization, no callus, no healing and at this time would be classified as a non-union.

A necropsy was performed the same day. Grossly, the fracture appeared as a large fibrous mass. The distal end of the proximal fragment was protruding from the mass and was not viable. Sagittal section of the femur revealed the fracture ends overriding and covered with fibrous tissue. There was no healing of the fracture.

Microscopically, the periosteum revealed increased connective tissue and blood vessels. There were PMN, macrophages, and plasma cells with chronic inflammation. The external callus showed coursely woven bone with little osteoblastic activity and was cartilagenous in character. There were fractures of the callus and pockets of inflammation between the bone spicules. The cortex was dead and dying bone with no osteoblastic or osteclastic activity with empty lacuna. The marrow cavity had marked internal callus with fine connective tissue and vessels. There was an area of bone abscess with liquifaction necrosis. The diagnosis was osteomyelitis and non-union fracture.

Calf Number 751

A 3-week-old Holstein bull calf was anesthetized, and the right rear leg was prepared for surgery. The right femur was exposed, fractured, and repaired with a Kirschner apparatus.[u] Two pins were placed in the proximal fragment and 3 in the distal fragment. Fixation was achieved by connecting the pins externally with a steel rod. The area was bathed in 1 million units of potassium penicillin[j] and closed

routinely. Postoperative radiographs revealed adequate reduction. The calf was up the same day of the surgery but was unable to bear weight on the affected limb. The calf was started on a 7-day course of Erythromycin[m] 200, 1 1/2 ml I.M. b.i.d.

Drainage from the pins was first noted on day 13. Radiographs on day 14 revealed the pins were out of the proximal fragment with overriding and malalignment. There was also evidence of lysis around the pins in the distal fragment.

The calf's temperature was 104°F on day 16 and the calf was again started on a course of Erythromycin.[m] The temperature on day 24 was still 104° and the antibiotic switched to penicillin-dehydrostreptomycin[o] 4 ml I.M. per day. The temperature was down to 101.2° on day 27.

The radiographs taken on day 28 revealed little change; however, the radiograph at 42 days showed mottling of the bone ends with overriding of 10 cm. There was increased periosteal reaction and sclerotic bone at the fracture ends.

Histologically, there was chronic inflammatory process in the periosteal area with pockets of PMN's and increased fibrous tissue. The cortex was dead and dying while the marrow showed irregular callus, fibrous tissue and osteomyelitis. A diagnosis of fracture, non-union, osteomyelitis was made.

Calf Number 749

A 4-week-old Holstein bull calf was anesthetized and the right rear leg prepared for surgery. The femur was exposed from the lateral approach, fractured as described, and repaired using a 7-hole ASIF standard broad plate[t] and 6 ASIF standard cortical screws.[t] A cerclage

wire was used to stabilize a chip fracture caused by bone clamps when securing the plate to the bone.

Postoperative radiographs revealed satisfactory alignment although 2 screws did not appear to be completely seated into the plate. This was due to the angle the screws were inserted into the plate.

The calf was fitted with a modified Thomas splint and started on a 7-day course of Erythromycin[m] 1 1/2 ml I.M. b.i.d. He was also given 1 Sulkamycin S[n] bollette daily for 4 days for a diarrhea problem.

The calf could get up on day 2 with difficulty and was able to ambulate around the stall. By the eighth day postoperatively the calf had no diarrhea, was eating well, had a temperature of 101°, and was active.

The 14-day radiograph revealed that 4 of the 6 screws were loose and the plate was not in contact with the distal fragment. The 28-day radiograph visualized a tremendous periosteal reaction with all of the 6 screws loose. The 42-day radiograph showed no change in the position of the fracture although the periosteal reaction had increased. Some lysis was noted around some of the screws. The calf was euthanatized with $MgSO_4$ IV and necropsied. Grossly, the bone was overriding with a 45° rotational malalignment. The plate was not in contact with the bone and all of the screws were loose.

Histologically, the cortical area showed hemorrhage, fibrin, and increased amount of fibrous tissue. The bone was dead and dying with a bone sequestrum and the callus formation was irregular. The marrow cavity revealed bone splinters and sequestrum with fine immature connective tissue. The diagnosis was fracture, malalignment, sequestrum.

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[n]Sulkamycin S, Norden Laboratories, Lincoln, NB 68501

Calf Number 738

A Holstein bull calf approximately 3 weeks of age was anesthetized and the right rear leg prepared for surgery. The right femur was fractured as described. It was repaired using a 6-hole broad plate[t] and 6 cortical bone screws.[t] The plate was bent to the contour of the bone. The area was bathed in 1 million units of potassium penicillin[j] in saline and closed routinely. The leg was placed in an Ehmer sling.

Postoperative radiographs revealed a midshaft fracture with a wide fracture gap. The #4 screw from the proximal end was not seated into the plate and the #1 screw was through only one cortex. The end of the plate did not appear to be in contact with the bone.

The calf was started on 2.5 ml Erythromycin[m] I.M. on day 1. The calf would stand with assistance on day 1, day 2, and day 3 but could get up by himself after day 3. On day 11 the temperature was elevated to 103.4° and the antibiotic changed from Erythromycin[m] to penicillin-streptomycin[o] 4 ml b.i.d. I.M. for 13 days.

The 14-day radiograph revealed some periosteal reaction and number 1 screw had backed out.

The calf ate well throughout the trial period. The 28-day radiograph revealed that screws 1, 3, and 4 were loose and the plate was away from the bone. The alignment was unchanged and the periosteal reaction was moderate.

The 42-day radiograph revealed all of the screws loose with callus formation and periosteal reaction with no change in alignment.

The calf was euthanatized with $MgSO_4$ and an immediate necropsy was performed.

Grossly, the screws were all loose and the plate was not seated onto the bone. There was much fibrous reaction around the bone. The

bone, which was cut longitudinally, showed necrosis around the screw holes and much fibrous reaction.

Histologically, there was marked external callus with osteoid formation and increased osteoblastic activity. The cortex was healthy and alive and the marrow was replaced with fine connective tissue with no hematopoetic activity. The bone spicules were partly covered with osteoblasts with little osteoid layed down.

The diagnosis was healing fractured femur.

Calf Number 750

A Holstein bull calf approximately 3 weeks of age was anesthetized and the right rear leg prepared for surgery. The femur was fractured as described. It was repaired using a 6-hole broad plate[t] and 6 cortical screws.[t] The area was bathed in 1 million units of potassium penicillin[j] in saline and routinely closed. The calf had no external fixation.

Postoperative radiographs revealed a slightly oblique midshaft fracture of the femur. Reduction was less than perfect with the fracture slightly overriding. The plate did not have good apposition to the distal fragment.

The calf was up, walking and eating on day 1. He was started on 1.25 ml Erythromycin[m] b.i.d. I.M. and kept on this schedule for 8 days.

The temperature rose to 103.2° on day 3 but was back to normal on day 15.

Radiographs at 14 days revealed that the proximal 4 screws and the most distal screw were loose. There was periosteal reaction at the fracture site with a mottling appearance in the proximal fragment. The fracture was overriding and malaligned at this time.

The 28-day radiograph revealed more periosteal reaction and more severe malalignment. The fracture gap was wider than previous radiographs had indicated. The bone plate had pulled away from both fragments.

The calf continued to walk on the leg, eat well, and have a normal temperature. The 42-day radiograph showed very little change other than an increased periosteal reaction.

The calf was euthanatized with $MgSO_4$, and a necropsy was performed the same day.

Grossly, there was overriding of the fracture with the plate pulled away from the bone. All of the cortical screws were loose. The femur was sagittally sectioned and found to have necrosis around the screw holes.

Histologically, the periosteum showed a fibrous cellular external callus. The cortex was alive and healthy although there was evidence of infection at the fracture site with an increased number of PMN's and plasma cells. The marrow cavity showed osteomyelitis with loss of hemopoetic activity. The spongy bone was dead and dying. There was hemorrhage with an increase in the number of macrophages, PMN's and immature fibroblasts.

The diagnosis was made of fractured femur, malalignment, and osteomyelitis.

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THE COMPARISON OF FEMORAL FRACTURE REPAIR IN YOUNG CALVES

by

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ABSTRACT OF THESIS

This work was prompted by an increase in the number of naturally occurring femoral fractures in young calves at Dykstra Veterinary Hospital with complications due to sepsis and immobilization. The experiment was designed to compare methods of fixation of fractured femurs in calves.

Twelve (12) Holstein calves were anesthetized and their right rear leg prepared for surgery. The right femur was fractured and repaired using 3 different methods.

Three (3) calves were repaired using bone plates and screws, 3 with Kirschner devices, 5 with intramedullary pins, and 1 calf served as a control with no internal fixation.

In an attempt to evaluate postoperative care, the calves were fitted with an Ehmer sling, a Thomas splint, or no external fixation. The control calf was fitted with a Thomas splint.

The calves were radiographed immediately post surgery and at 2-week intervals for 6 weeks.

The calves were euthanatized 6 weeks post surgery and the femur removed and photographed. Histopath studies were done on the femur at the fracture site.

The results indicated the major problems with femoral fracture in young calves is sepsis and immobilization.

Immobilization was best achieved by the use of multiple intramedullary pins which were adequate to allow healing to occur. The Kirschner devices were totally inadequate allowing severe overriding and malalignment. At the time of necropsy the calves with the Kirschner devices were

all termed non-unions. The calves fixed with plates and screws did not heal well because the screws loosened and allowed the fracture to break down.

All of the calves with the Kirschner devices, 1 calf with intramedullary pins, and 1 calf with a bone plate developed osteomyelitis.

The calves equipped with the Thomas splints and those with no external fixation were able to stand and ambulate much quicker and with less difficulty than the calves with the leg placed in an Ehmer sling.

It was determined that the calves with the Thomas splints and those with no external fixation could stand and ambulate sooner and more efficiently than the calves with the Ehmer slings. There was no substantial difference in the healing of the calves with different types of external fixation.