OPEN REDUCTION AND FIXATION OF ACETABULAR FRACTURES IN THE DOG

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ABSTRACT

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An investigation was made into methods of surgical management of pelvic fractures in the dog. The methods explored were: (1) external fixation by mechanical devices and (2) open reduction and internal fixation with screws, pins and plates. Pelvic fractures were created experimentally by driving the femoral head against the acetabulum by means of force applied to the greater trochanteric area of the femur. The paper reports on a series of ten acetabular fractures. In this series, unilateral acetabular fractures were repaired by open reduction and internal fixation. The fracture site was exposed by Brown's (1953) dorsal surgical approach to the coxofemoral joint; the fracture was reduced mechanically with a large modified towel clamp and fixed with a single stainless steel screw inserted across the fracture line. Results were variable, ranging from restoration of normal function to severe lameness because of avascular necrosis of the femoral head. All ten cases showed moderate to

marked fibrosis of the coxofemoral joint capsule at necropsy.

OPEN REDUCTION AND FIXATION OF ACETABULAR FRACTURES IN THE DOG

By

James Stanley Larsen

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Table of Contents

List of Tables

List of Figures

Chapter I

Introduction

With advent of the automobile, there has been an increase in the number of fractures occurring in dogs. According to Brinker (1959), pelvic fractures comprise 16.4 per cent of all fractures seen in the dog. This is the second most common type, only femoral fractures occurring more frequently. In spite of these significant numbers, the management of pelvic fractures has not changed measurably in recent years, as contrasted to other advances in canine orthopedics.

The conservative treatment of pelvic fractures, that of confinement and supportive care, is practical and effective in many cases but what happens to those cases of severe displacement and acetabular involvement which do not respond to conservative treatment? Too often lameness, deformity, obstipation and dystocia are the end results of severe acetabular fractures.

This dissertation deals with the surgical management of experimentally produced pelvic fractures and a method of open reduction and fixation of acetabular fractures by means of a bone screw.

In this study the principle stated by Knight and Smith, (1958) "That the more anatomical the reduction, the earlier will be the return to function; and the more nearly normal the result, the less frequently will degenerative changes develop," served as a guide.

Chapter II

Literature Review

A. Anatomical Considerations

The word pelvis (L. "basin") has been defined as the basin-shaped ring of bone at the posterior extremity of the trunk supporting the spinal column and resting upon the lower extremities. It is composed of the two innominate bones laterally and ventrally, and the sacrum and coccyx dorsally (Dorland, 1951).

The acetabulum (L. "vinegar-cruet") is a cup-shaped cavity on the lateral surface of the os coxa in which the head of the femur articulates. op. cit. This joint cavity is formed where the ilium, ischium and pubis meet. These three bones, along with the small acetabular bone located in the wall of the acetabulum, fuse at about the fourth month in the dog (Miller, 1948).

Twenty-five muscles attach directly to the pelvic bones. They can be classified into four main groups according to function: (1) extensors of the hip joint supplied by the sciatic nerve, (2) flexors of the hip joint innervated by the femoral nerve,

(3) adductors of the hip joint supplied by the obturator nerve and (4) abductors and extensors of the hip joint supplied by branches of the sciatic nerve.

The femoral nerve is most often formed by branches of the fourth, fifth and sixth lumbar nerves. It passes through the ilio-psoas muscle to which it supplies branches and ends in the anterior thigh muscles. The sciatic nerve is formed by branches of the last two lumbar and first and second sacral nerves. It penetrates the greater sciatic foramen to supply the posterior muscles of the thigh. The obturator nerve derives its origin from fibers of the fourth, fifth and sixth lumbar nerves. It courses along the medial surface of the shaft of the ilium and disappears through the obturator foramen to supply the external obturator, pectineus, adductor and gracilis muscles (Miller, 1948).

B. Etiology and Incidence of Pelvic Fractures

A tremendous amount of force is required to fracture the pelvis. In a survey of fifty-six cases of human pelvic fractures, Conway (1935) stated that 46 per cent were the result of falls from great height and 41 per cent from automobile accidents. In the production of fractures on skeletal human femora, still articulated with the pelvis, Smith (1953) calculated a force of 288 foot-pounds applied to the femur was necessary to fracture the acetabulum.

In a survey of fifty canine and feline pelvic fractures presented to the small animal clinic at Michigan State University, automobile accidents were responsible for all of the cases except one which was caused by being run over by a wagon. In nearly all these cases, fractures involved more than one of the pelvic bones. The incidence of involvement was: pubis, 86 per cent; ischium, 44 per cent; acetabulum, 40 per cent; ilium, 38 per cent; sacroiliac, 16 per cent. Ten of these cases were managed with intramedullary pinning, three by Kirschner half-pin assemblies, three by euthanasia and the rest treated by cage rest and supportive care. Leonard (1960) stated that pelvic fractures comprised 23.5 per cent of all fractures seen at the Cornell small animal clinic, and of those, 89 per cent involved the ilium.

C. Management of Pelvic Fractures--Veterinary

Ehmer (1934) advised conservative treatment of canine pelvic fractures by attempting to press the bones into place, confining the animal in a small area and making it as comfortable as possible. He described the single sling and the spread cast for use in some types of pelvic fractures, but added that most casts do little or no good and only add to the misery of the animal.

Knowles et al. (1949) advanced the use of the Kirschner half-pin splint in cases of acetabular involvement or where displacement of parts was such as to result in unsightly lameness. They emphasized the importance of careful radiographic interpretation and the selection of a fragment of bone that was solid to form an anchor for the splint. The realignment of parts was determined by digital palpation per rectum and by radiographs. Olsen (1959) recommended the Kirschner splint for the management of separation of the symphysis pubis, sacroiliac separation and acetabular fracture. He chose the tuber sacrale, shaft of the ilium, body of the ischium and the tuber ischii as locations for the placement of the pins. He stated that usually the pins and pin assembly could be removed in two or three weeks. Henley (1955) reported the successful management of a case of pelvic and femoral neck fracture with the Kirschner splint and a femoral head prosthesis.

Brinker (1959) classified pelvic fractures into three groups: (1) those which heal satisfactorily without specific treatment, (2) those benefited by specific treatment and (3) those damaged beyond satisfactory repair. He advocated the use of threaded shoulder pins instead of trocar point pins when used with half-pin assemblies. In cases involving the acetabulum, he suggested an open approach to the coxofemoral joint to allow prying the fracture segments into alignment and the insertion of intramedullary or diagonal pins for fixation. Injury of nerves, urethra, bladder and intestine were mentioned by Brinker as complicating soft tissue sequelae of pelvic fractures. The absence of urine after catheterization helped to diagnose rupture of the urinary bladder. He discouraged the use of casts in the treatment of pelvic fractures since casts tend to push the fractured bones into the pelvic canal.

In regard to the symptomatology of pelvic fractures, Leonard (1960) made the following observations. Fractures of the pelvis were often multiple but seldom compound and pain was a constant sign, but crepitus might be difficult to elicit except in impacted fractures of the acetabulum. In fractures of the shaft of the ilium, the patient was usually able to sustain weight but walked with difficulty. When the body of the ischium or tuber ischii was fractured there was an intermittent lameness of five to seven days. Separation of the symphysis pubis caused inability to rise or bear weight. Fractures through the acetabulum were characterized by a unilateral lameness, abduction of the limb and limited joint movement. When intrapelvic luxation of the femoral head was present, the trochanter major was depressed, the rump appeared flattened and the affected limb was shorter than its mate. In the treatment of pelvic fractures, Leonard recommended the Kirschner splint used in conjunction with beaded wires or bicycle spokes placed through parts of the pelvis near the surface so that a clevis can be formed with a pin bar to prevent the pins from retracting. He stated that some impacted fractures of the acetabulum can be managed by straight leg traction to reduce the fracture, and the application of a Thomas splint for ten days to two weeks.

Cawley and Archibald (1955) described an open approach with intramedullary pinning for fractures of the shaft of the ilium. The fracture site was exposed by incising the skin over the tuber sacrale and reflecting the origin of the middle gluteal muscle. Fixation was accomplished by a pin inserted in the medial side of the ilial wing into the ilial shaft across the fracture line.

A dorsal surgical approach to the coxofemoral joint was described by Brown (1953) for the insertion of femoral head prostheses in the dog and cat. In this approach, the skin was incised over the greater trochanter and deepened to expose the anterior border of the biceps femoris muscle. The biceps and tensor fascia lata were separated to expose the gluteal muscles. The superficial, middle and deep gluteal muscles were transected near their insertions and reflected dorsally to expose the coxofemoral joint. Closure was accomplished by suturing the severed muscle attachments starting with the deep gluteal muscle. A small hole was drilled through the dorsal lip of the greater trochanter and a double suture passed through it into the thick band of tissue found in the middle gluteal muscle. The animal's leg was abducted and the closure completed by suturing the rest of the middle gluteal, the superficial gluteal and biceps muscles to the severed fascia lata. A figure-eight single sling bandage was applied and left on the leg for five days. In a similar dorsal surgical approach Gorman (1955) performed an osteotomy of the greater trochanter to leave the large middle gluteal muscle firmly attached to bone. Upon closure of the surgical wound, the greater trochanter and the attached muscle were returned to their normal positions and held in place with stainless steel wire.

Archibald _et al_. (1953) described an open approach (attributed to Bottareli) to the coxofemoral joint for the correction of coxofemoral luxations. Exposure of the joint was made by separation of the vastus lateralis and rectus femoris muscles.

A ventral surgical approach to the acetabulum was reported by Rieger (1956) in which the pectineus muscle was transected and reflected to expose the acetabulum. Once exposed, acetabular fragments were fixed with stainless steel wire.

D. Management of Pelvic Fractures--Human

In human medicine, pelvic fractures historically have been treated conservatively. "The treatment consists of binding the pelvis with a circular bandage" is a typical statement from older surgical volumes (Skey, 1851). Plaster of paris double hip spicas (Rose, 1951; Watson-Jones, 1955) or leg traction and hammock suspension (Nowland and Conwell, 1933) have been recommended.

Recently more radical treatments have been employed for severe pelvic fractures. Key and Conwell (1942) suggested fixation with small bone or ivory pegs. Levine (1943) treated a case of central acetabular fracture with a bone plate curved to fit the inner table of the pelvis. Whiston (1953) described correction of a fractured ilial wing by subperiosteal dissection to expose the fracture site and fixation with two stainless steel pins.

Elliott (1956) in a paper on central fractures of the acetabulum stated the mechanism of this injury was force applied to the greater trochanteric region, the head of the femur being driven centrally against the floor of the acetabulum thus fracturing the acetabulum. This fracture was observed in young adults or middle-aged adults, since in older age groups the neck of the femur fractured first, as a rule. He mentioned that a high incidence of traumatic arthritis and frequent avascular necrosis of the femoral head were present in this type of fracture, which accounted for the poor prognosis. In two cases he achieved a successful anatomical reduction by the use of Hagie pins inserted across the fracture line. The Hagie pins used were small lag screws with threaded shafts upon which a nut and washer could be placed to compress the fragments. The Smith-Peterson anterior iliofemoral approach was used to expose the acetabulum.

External fixation was employed by Johnson (1957) to repair a comminuted pelvic fracture with avulsion of one-half of the pelvis from the other. A turnbuckle was used to approximate the fragments.

Stewart and Milford (1954) while showing contempt for surgical management of comminution of the acetabulum, stated these tenets: (1) that dislocation of the hip is an emergency demanding immediate reduction; (2) that postoperative immobilization is necessary only to maintain stability; (3) that avascular necrosis is the end result of disruption of the blood supply to the femoral head. Speed and Knight (1956) avowed that it is essential to restore the normal anatomy of the hip as nearly as possible and that any incongruity in the acetabular wall is certain to produce a degree of traumatic arthritis.

Knight and Smith (1958) used the face of a clock to describe central acetabular fractures, twelve o'clock being the top of the acetabular crescent. They felt that it was most important to restore the weight-bearing vault of the acetabulum or that area between two and ten o'clock. Emphasis was placed on the importance of careful study of stereoscopic radiographs for the correct interpretation of fractures and proper choice of approach. They presented several cases of central acetabular fractures which were managed surgically by anterior or posterior approaches to the acetabulum and reduction by grasping pegs inserted into each fragment with bone pliers. Fixation was accomplished with Knowles pins inserted across the fracture site. Aftercare of the patient with pelvic fracture was greatly simplified by an anatomical open reduction. Fixation and the return to function was more rapid than following treatment by conservative methods.

Chapter III

Materials and Methods

A. Preliminary Investigative Procedures

At its inception this study was to be one of pelvic fractures in the dog. Hope was high concerning the utilization of a Roger Anderson Tru-Aligning Splint*, a device for the reduction of human long bone fractures, for the reduction of pelvic fractures in the dog. After extensive modification and machine work of the model owned by the Department of Surgery and Medicine (figure 1.), reductions of several cases of pelvic fracture were attempted. Corkscrews and Steinman pins bent to form hooks were used to grasp the bony pelvis and these in turn were fastened to the modified Roger Anderson splint. When attached in this manner the fractured segments were manipulated by adjustment of the many levers, joints and screws on the device. Once reduction was achieved, immobilization was effected with Kirschner** or Tower* assemblies.

Common turnbuckles were adapted to Kirschner equipment to form an adjustable splint (figure 2.). A Steinman pin was driven through both ilial wings just posterior to the spinous process of the last lumbar

*The Tower Company, Inc., Seattle, Washington
**Kirschner Manufacturing Co., Vashon, Washington

Figure 1. A modified Roger Anderson Splint showing two corkscrews clamped in place and an 8-inch X 10-inch cassette holder over the apparatus.

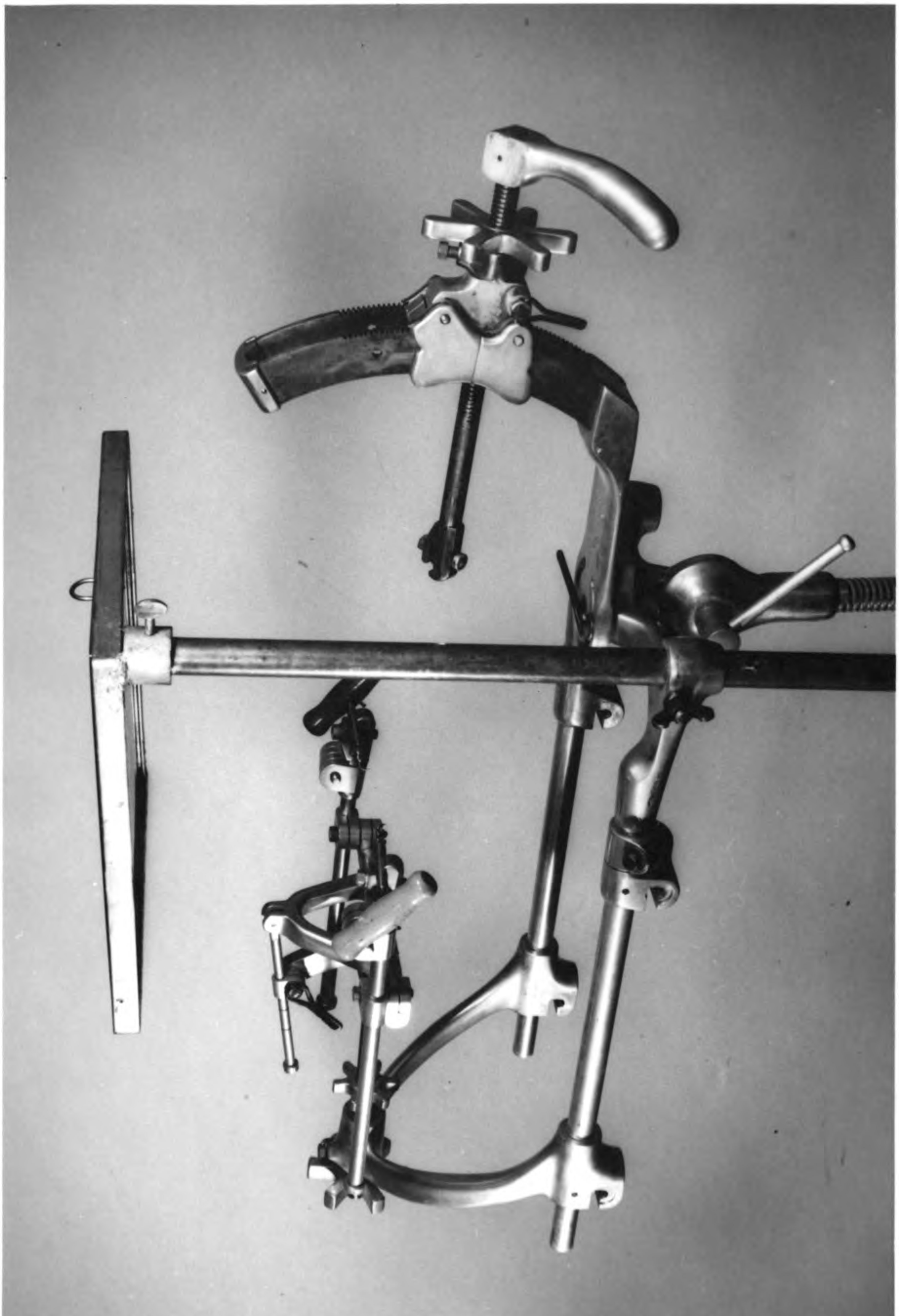

Figure 1.

Figure 2. Lateral and dorsal views of a skeletal pelvis showing turnbuckles adapted to Kirschner clamps and attached to the pelvis with bone pins.

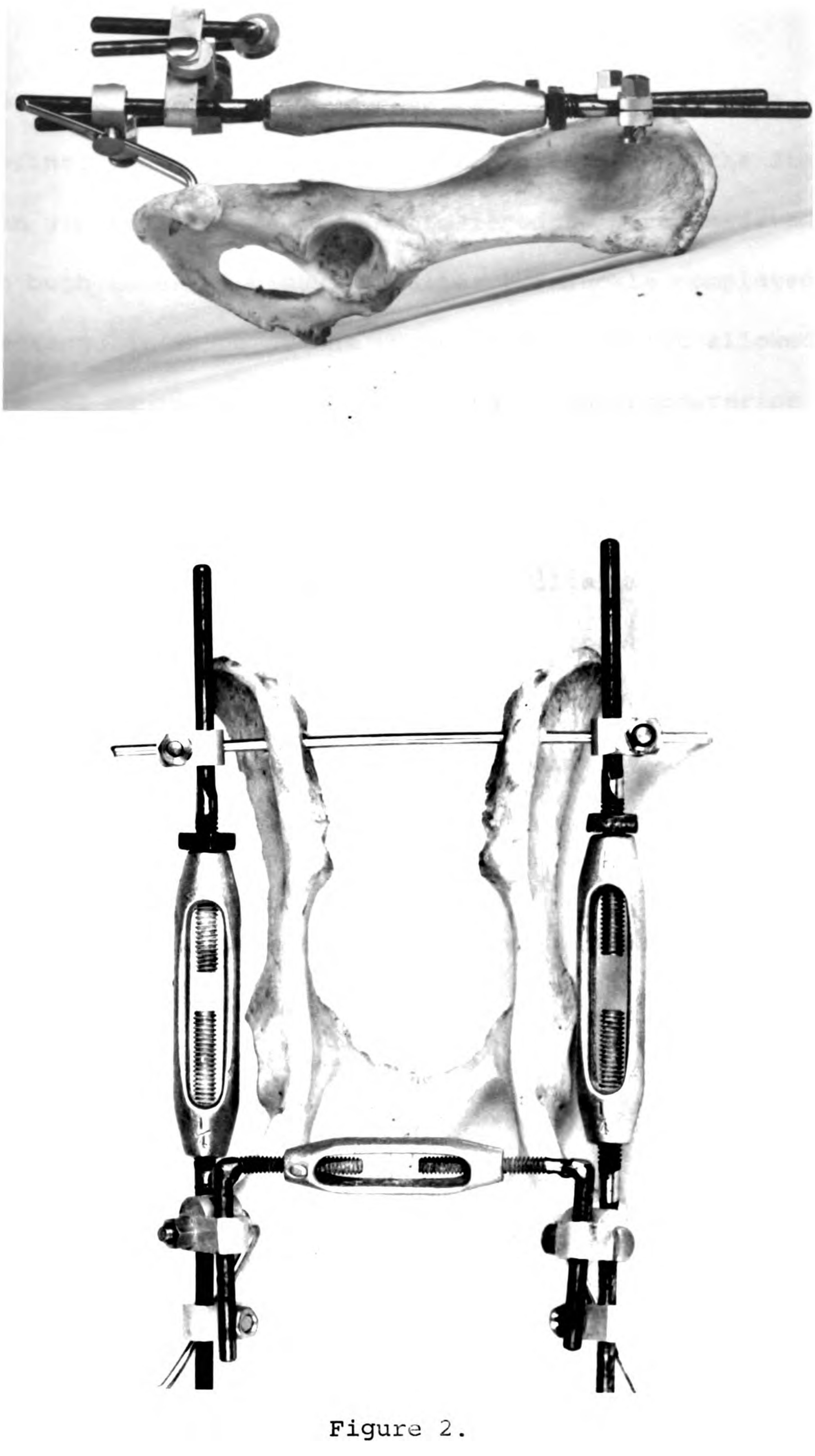

Figure 2.

vertebra to form a solid base from which to build a splint. Adapted turnbuckles were attached to the Steinman pin at right angles and fastened to pins inserted into both tuber ischia. A smaller turnbuckle completed the rectangular shape of the splint. This splint allowed gradual manipulation of fragments in anteroposterior and lateromedial directions.

Several surgical approaches to the pelvis were tried. The dorsal approach to the ilial shaft (Cawley and Archibald, 1955), the ventral approach to the acetabulum (Rieger, 1956), the dorsal approach to the coxofemoral joint (Brown, 1953) and a perineal approach to the ischium. The latter consisted of an incision similar to the one made in perineal herniorrhaphy and enabled the operator to palpate the ilial body once the skin was incised and fascia separated.

The use of Steinman pins, bone screws, bone screws and standard bone plates, bone screws and homemade malleable metal bone plates shaped to fit the pelvis, and sheet metal rivets was explored in the fixation of a variety of pelvic fractures produced on cadavers and mascerated bony pelves.

Considerable difficulty was encountered in creating pelvic fractures severe enough to warrant radical treatment without causing death from shock or hemorrhage. When dogs anesthetized with sodium pentobarbital* were struck over the pelvis with a sledge hammer, fatal shock was frequent. Clamping the posterior quarters of anesthetized dogs in a large vise was totally ineffective. Femoral head and neck fractures were common unwanted sequelae to severe blows over the trochanter major.

B. Experimental Design

It was decided that the problem should be restricted to acetabular fractures in an attempt to narrow the field of endeavor. Thirty dogs of mixed breeding obtained from a dog pound were selected for the final problem. The animals were housed in individual cages in a kennel. A ration composed of two cups F/D** supplemented with 30 ml of corn oil and 5 ml of cod-liver oil mixed with two cups of water was fed once daily on a weight basis. For example, a twenty-pound dog received two and one-fourth cups of the ration. The dogs were vaccinated against canine distemper, infectious canine hepatitis and leptospirosis. In only ten were suitable acetabular

*Halatal, Jensen-Salsbery Laboratories, Inc., Kansas City, Missouri

**"Prescription Diets Dept.", Hill Packing Co., Topeka, Kansas fractures produced and these ten dogs were used as the final experimental group.

Each dog was anesthetized with thiamylal sodium* and placed in lateral recumbancy on the floor with the right side down. The left leg was flexed and held in this position by means of a single sling of one-inch adhesive tape to prevent excessive movement of the leg (figure 3.). Cloth pads were placed under the right hip to help cushion the blow and prevent fracture of the right pelvic bones. A three-legged striker was placed over the dog with its striking plate directly over the greater trochanter of the left femur. The top of the striker was hit sharply by a full swing of a five-pound sledge hammer to drive the femoral head against the acetabulum (figure 3.). After the blow the pelvis was palpated rectally to estimate the amount of pelvic disruption. Ventro-dorsal and lateral radiographs were taken and studied with a skeletal pelvis in hand to help visualize the fractures.

C. Materials

In addition to the ordinary surgical instruments, special orthopedic devices were used as follows: (figure 4.)

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*Surital, Parke, Davis & Co., Detroit, Michigan

Figure 3. Diagramatic illustrations showing an anesthetized dog in lateral recumbency with a tape sling in place and a three-legged striker in place over the greater trochanter and the direction of applied force.

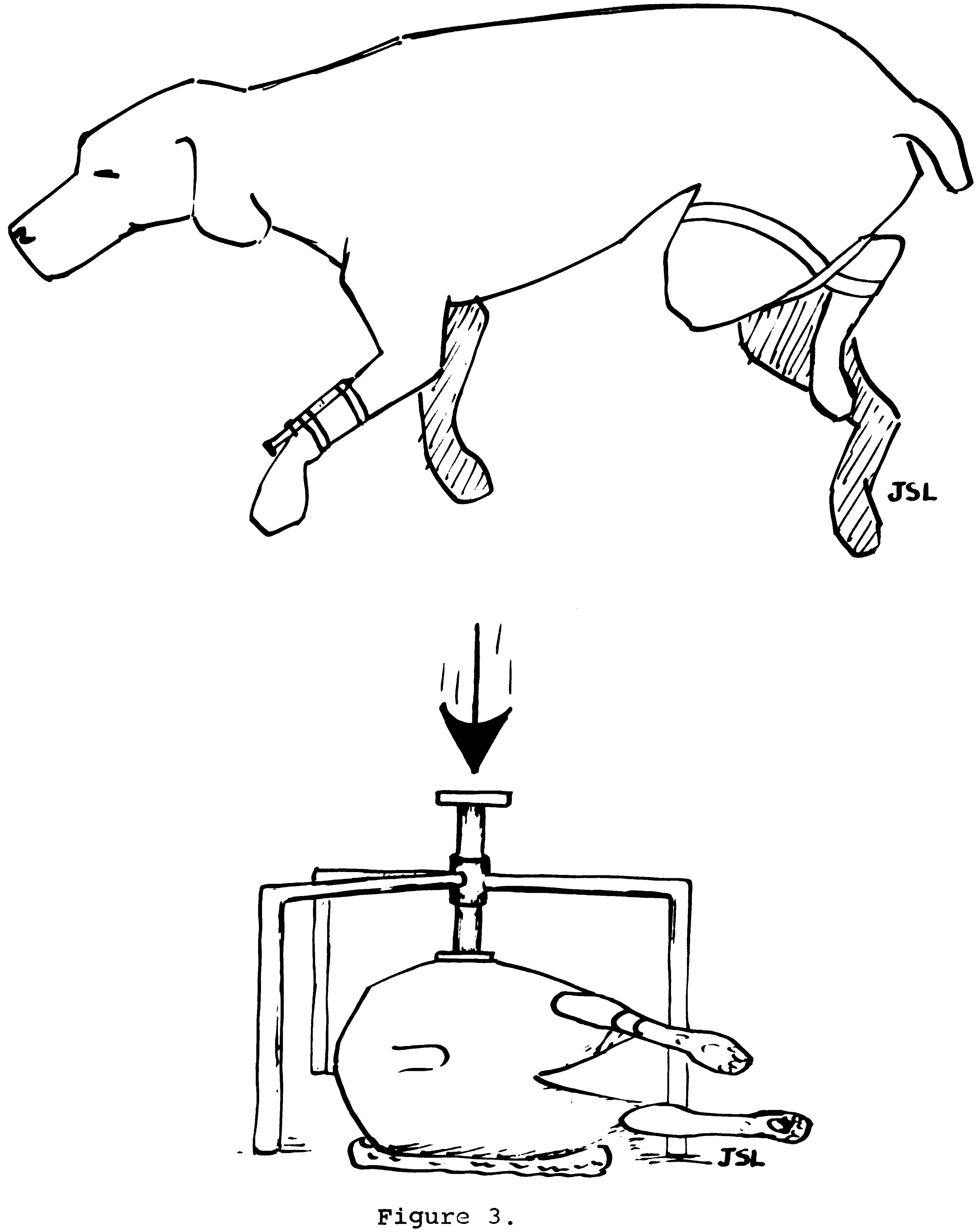


Figure 3.

Figure 4. Orthopedic instruments used in the reduction and fixation of acetabular fractures. A. An intramedullary pin drill and Steinman pin, B. Drill key, C. Large Backhaus towel clamp with straightened prongs, D. An assortment of headless bone screws, E. Small screw driver.

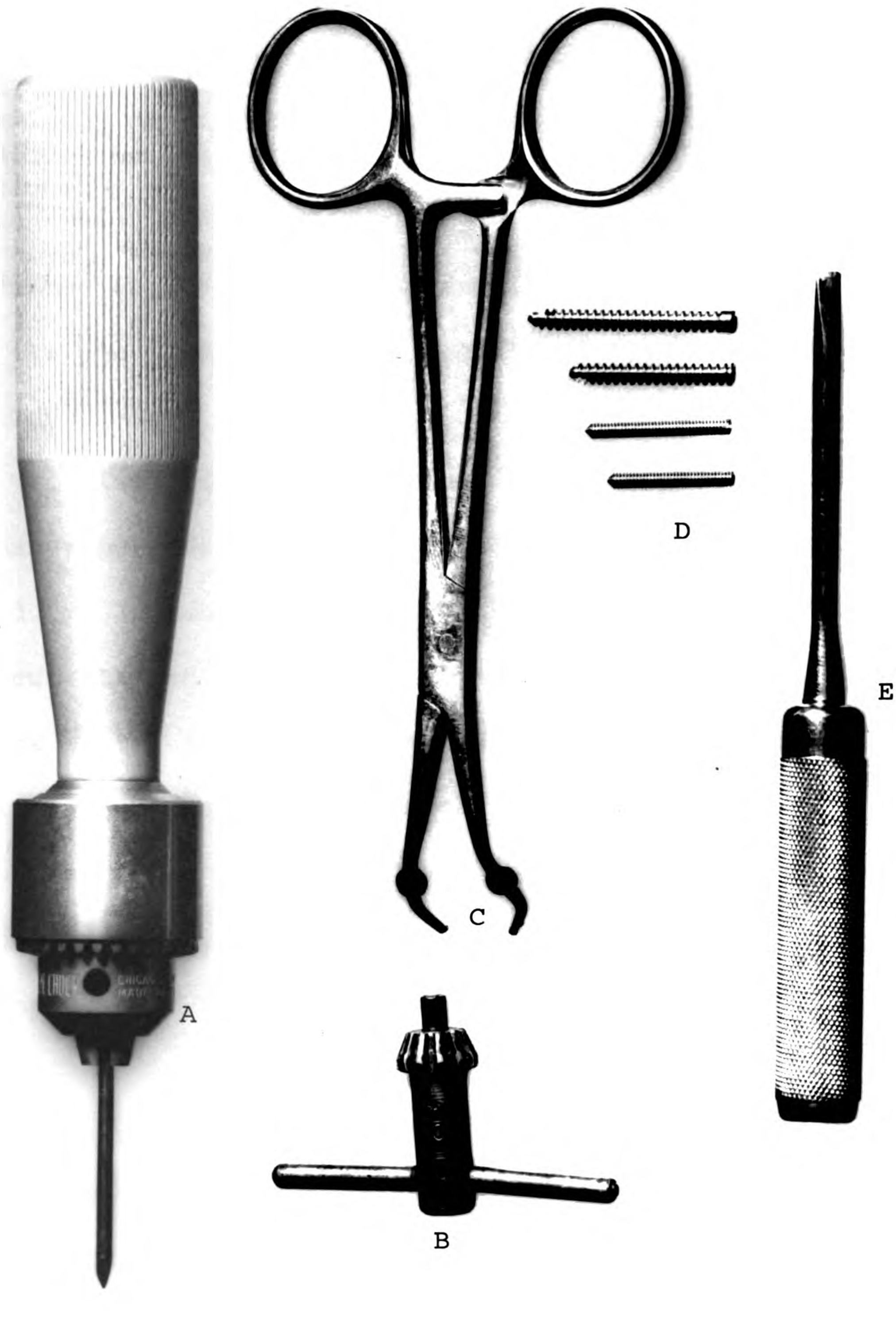


Figure 4.

1 Kirschner intramedullary pin drill
1 Large Backhaus towel clamp with tips straightened and cut off
Headless, stainless steel bone screws
1 Small screw driver
2 Steinman pins, .080 and 3/32 inch diameters
1 Osteotome
1 Straight two-inch needle
30-gauge stainless steel surgical wire

This equipment was made into a pack and sterilized in an autoclave.

Two kinds of stainless steel bone screws were used: Sherman-type, coarse-thread, .138-inch-diameter and fine-thread, 3/32-inch-diameter. The heads of these screws were cut off and the top of the shank slotted. The final lengths of the screws used were 3/4-inch, 7/8-inch and one-inch. Screws prepared in this manner were obtained by special order from the Zimmer Manufacturing Company of Warsaw, Indiana. It was felt that removal of the standard head would provide a neater junction of screw and bone.

D. Surgical Technique

On the day following the fracture, each dog was anesthetized with sodium pentobarbital and placed on an operating table on its right side. The hair of the left hip was clipped from the dorsal midline to the stifle extending from the flank to the anus, with a #40-blade Oster clipper. The skin was cleansed for surgery five times with germicidal detergent* and covered with a sterile drape in which there was an eight-inch opening. The dorsal surgical approach to the coxofemoral joint as described by Brown (1953) was employed on all dogs in the final experimental group.

After the coxofemoral area was exposed, the fracture site was determined and freed of adherent muscle fibers by use of an osteotome. In some instances it was necessary to sever the tendon of the internal obturator muscle to obtain adequate exposure. A finger was then forced over the dorsal border of the acetabulum and into the pelvic canal. By digital manipulation the bone fragments were brought into apposition and any medial displacement corrected. It was found helpful to grasp the tuber ischii with a towel clamp to aid in the reduction of the ischial fragment.

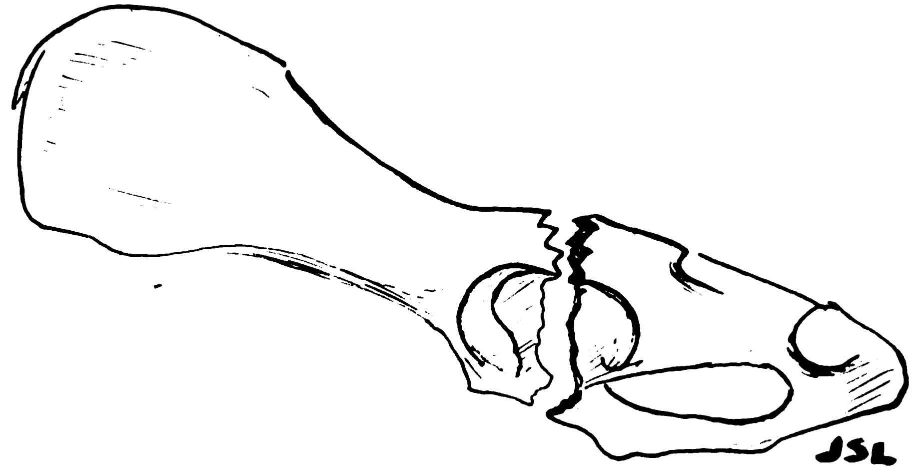
When reduction had been achieved, a hole was drilled with a 3/32-inch trocar point Steinman pin on either side of the fracture site through the lateral cortex of the pelvis. The straightened prongs of a Backhaus towel clamp were inserted into these holes, final reduction was made

*Parke, Davis & Co., Detroit, Michigan

and then the towel clamp was tightly closed. Since a central acetabular fracture presents a triangular fracture surface, the break was nicely immobilized when the towel clamp was closed (figure 5.).

Following reduction, a trocar-point Steinman pin, the size of which was equal to the inside diameter of the chosen screw was driven obliquely across the fracture line from the extreme dorsum of the ilial fragment downward into the ischial fragment. In heavily muscled dogs it was necessary to penetrate the middle gluteal muscle with the pin to obtain the proper angle across the fracture line. After the hole was drilled, a headless screw of the proper length, as determined by drill-pin penetration, was screwed firmly across the fracture line with a small screw driver (figure 5.). The towel clamp was removed after the screw was in place and the stability of the repair was tested. The joint capsule was sutured if possible, but generally it was torn beyond repair. The incision was closed after the manner of Brown (1953). In several of the larger dogs the lip of the greater trochanter was cut off with an osteotome and mallet upon entry and

Figure 5. Lateral views of a central acetabular fracture showing method of reduction with the towel clamp in place and the direction of the bone screw being inserted across the fracture line.



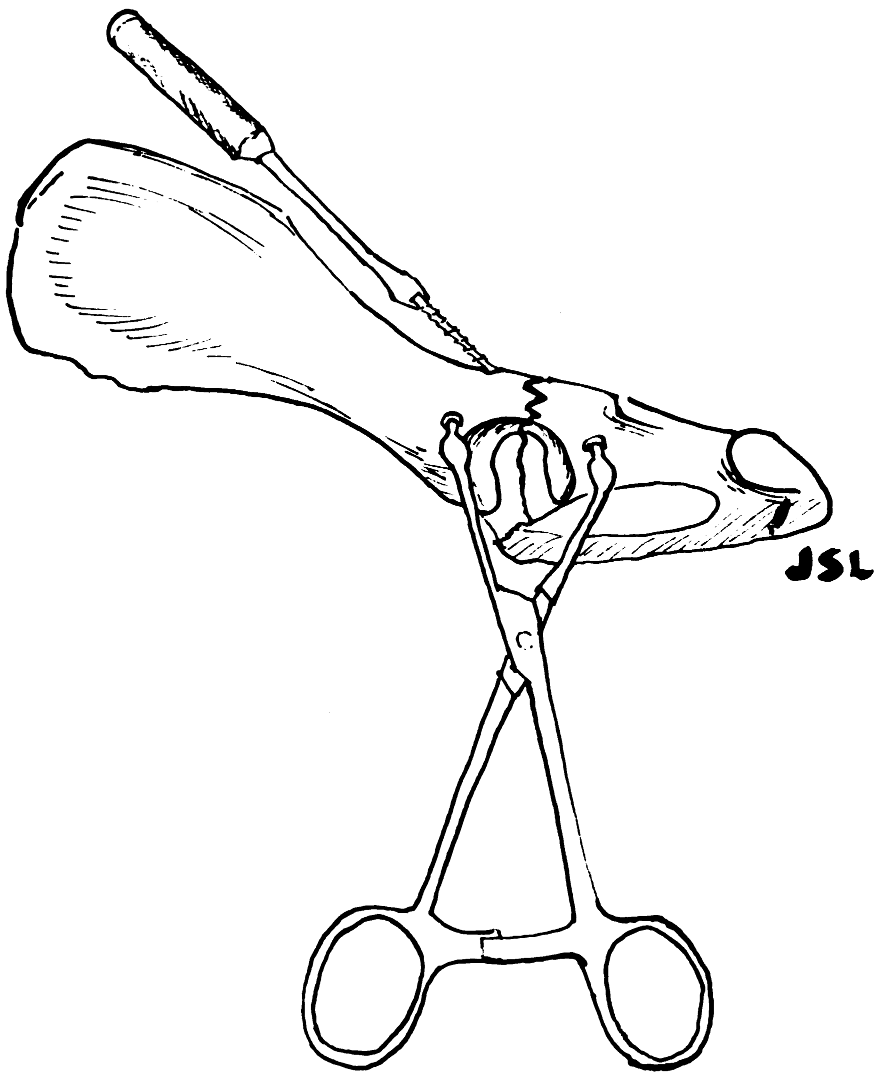


Figure 5.

wired back in place with two interrupted sutures of stainless steel wire on closure after Gorman's technique (1955). This was an attempt to obtain a firmer attachment of the middle gluteal muscle.

Exceptions to this general regimen were as follows: (1) in Dog M-4, four months old, the pelvic bones were not strong enough to keep the towel clamp prongs from tearing through the bone when clamped shut, so a Steinman pin was driven across the fracture site and the end cut next to the ilium; (2) in Dog M-11, a stainless steel screw was used for fixation of a fractured greater trochanter; (3) in Dog K-26, an intramedullary pin was used to fix a femoral neck fracture.

Ventro-dorsal and lateral radiographs were taken at the completion of each operation.

Aftercare consisted of cage rest and the prevention of weight-bearing of the left leg by a single sling of adhesive tape. The sling was removed after two to three days or, in cases of femoral neck fracture, after ten days. At the time the cages were cleaned, the dogs were allowed to romp together. This was the only exercise they received.

E. Method of Evaluation

The dogs were clinically evaluated after periods ranging from sixty-eight days to one hundred forty days and then euthanasia was performed with sodium pentobarbital. The evaluation consisted of observation of the animal when standing, at a walk, and at a run. The functional range of the coxofemoral joint was determined by manual manipulation and the fracture callus was palpated per rectum. Ventro-dorsal and lateral radiographs were taken at the time of euthanasia.

A necropsy was performed on each dog. The pelves and femora of the animals were saved and cleaned of tissue after soaking in hot water. Thirty-five-millimeter colored slides were made from photographs of the live animal at the time of evaluation and later of the mascerated pelves and femora. Line drawings were traced from ventro-dorsal radiographs of the pelves showing the original fractures, fixations and final radiographic results.

Chapter IV

Results

See Tables I, II and III; Figures 6, 7, 8, and 9.

In every case of pelvic fracture produced in this study, the left and right pubic bones were broken.

Rupture of the urinary bladder was conspicuously absent from the dogs in which pelvic fractures were created experimentally. This was also true in the survey of fifty cases of naturally acquired pelvic fractures made by the author at Michigan State University.

All the dogs in the experiment showed moderate to marked fibrosis of the coxofemoral joint capsule. Fluid was present within the joint whether the joint capsule was sutured at the time of reduction or was torn beyond repair.

Table I. Experimentally produced pelvic fractures

Dog Number	Weight Lbs.	Sex	Age (Months)	Description of fractures	Attitude of dog on first post-fracture day
M-4	15	M	4	L. acetabulum, sacroiliac luxation, L. femoral neck, L.&R. pubes, medial displacement.	Attempted to walk.
M-10	17	F	12	L. acetabulum, L.&R. ischia, L. & R. pubes, medial displacement.	Attempted to rise.
M-11	28	M	12	L. acetabulum, L. greater trochanter, L.&R. pubes, no medial displacement.	Did rise, unable to walk.
M-20	31	M	24	L. acetabulum, L.&R. pubes, no medial displacement.	Did walk.
M-22	18	F	24	L. acetabulum, L. ischium, L.&R. pubes, medial displacement.	Unable to rise. Spread-eagle position.
K-20	22	M	10	L. acetabulum, L. femoral neck, capital epiphysis, greater trochanter, L.&R. pubes, medial displacement.	Did rise. L. leg useless.
K-23	28	M	12	L. acetabulum, R. acetabulum, L.&R. pubes, some medial displacement.	Would not rise.
K-25	45	F	12	L. acetabulum, L. ischium, L.&R. pubes, some medial displacement.	Did rise and stand.
K-26	25	F	12	L. acetabulum, L. femoral neck, L.&R. pubes, medial displacement.	Unable to rise.
K-27	23	M	12	L. acetabulum, L. femoral neck & greater trochanter, R. ischium, L.&R. pubes, severe medial displacement.	Unable to rise. Spread-eagle position.

Table II. Clinical evaluation of healed pelvic fractures

Dog Number	Days post-operative	Evaluation of function: Supportive	Evaluation of function: Locomotive	Palpation of coxofemoral joint	Rectal Palpation
M-4	131	Favored L. leg.	Favored L. leg.	Pain & crepitus.	Narrowing of pelvic canal.
M-10	124	Carried L. leg.	Used L. leg with limp. Stifle adducted.	Coxofemoral joint stiff.	Slight narrowing of pelvic canal.
M-11	117	Normal.	Normal.	Normal.	Normal.
M-20	140	Normal.	Normal.	Normal.	Normal.
M-22	134	Normal.	Slight lateral swing of left leg.	Normal.	Some narrowing of pelvic canal.
K-20	129	L. leg adducted.	Favored L. leg. Swinging leg lameness.	Restriction of movement.	Normal.
K-23	123	Normal.	Slight crouch.	Normal.	Narrowing of pelvic canal.
K-25	83	Adduction of stifle.	Favored L. leg. Swinging leg lameness.	Normal.	Some narrowing of pelvic canal.
K-26	73	Normal.	Normal.	Normal.	Normal.
K-27	68	Adduction of stifle.	Favored L. leg. Swinging leg lameness.	Pain & crepitus.	Some narrowing of pelvic canal.

Table III. Description of healed fracture sites of macerated pelves and femora

Dog Number	
M-4	Massive connective tissue proliferation around coxofemoral joint. Femoral neck fracture healed with mal-position of head.
M-10	Inner bony table of acetabulum gone. Central and marginal erosions of femoral head.
M-11	Connective tissue proliferation around left and right acetabula. Bony pelvis essentially normal.
M-20	Bony pelvis essentially normal.
M-22	Screw was loose. Moderate fibrosis around joint. Pelvic canal narrowed moderately.
K-20	Acetabulum collapsed with roughened articular surface. Necrosis of femoral neck. Femoral head healed in mal-position on proximal femoral shaft.
K-23	Left and right acetabula gave the same appearance. Fibrosis of both coxofemoral joints. Pelvic canal narrowed one-half normal size.
K-25	Some dorsal displacement of ischial fragment. Some bony proliferation at edge of femoral head.
K-26	Bony pelvis essentially normal. Femoral neck fracture healed. Inner bony table of acetabulum gone.
K-27	Loss of crescent shape of acetabulum. Roughened articular surface. Aseptic necrosis of femoral head and neck.

Figure 6. Photograph of line drawings made from ventro-dorsal radiographs showing the dog number, and from left to right, the original fracture, immediate postoperative appearance and the final radiographic result at the time of euthanasia.

Figure 7. Photograph of line drawings made from ventro-dorsal radiographs showing the dog number and from left to right, the original fracture, immediate postoperative appearance and the final radiographic result at time of euthanasia.

Figure 7.

Figure 8. Dog K-26, a favorable example. The ventro-dorsal view shows the restoration of normal pelvic structure and minimal bony callus formation at the acetabular and femoral neck fracture sites. The lateral view shows a normal crescent-shaped acetabulum.

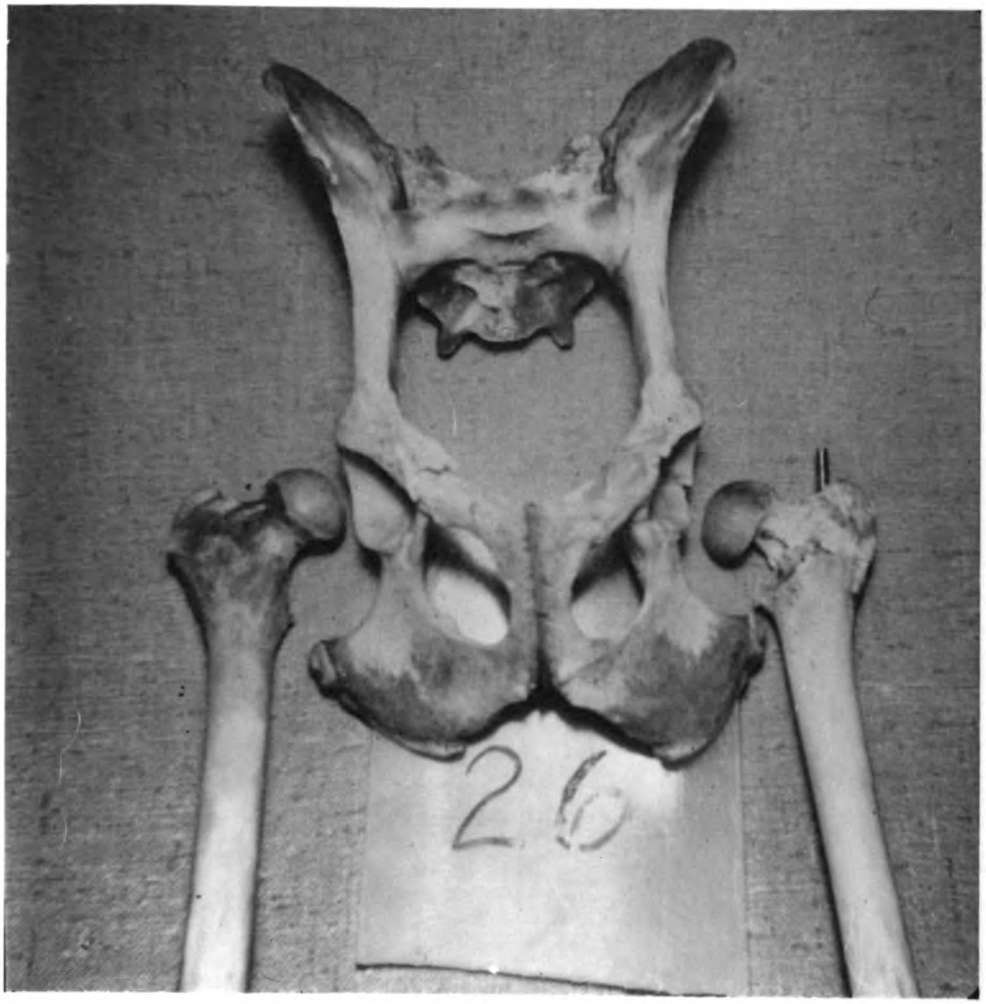


Figure 8.

Figure 9. Dog K-27, an unfavorable example. The ventro-dorsal view shows bony proliferation of the fracture sites and avascular necrosis of the femoral head. The lateral view shows bone proliferation around the acetabulum.

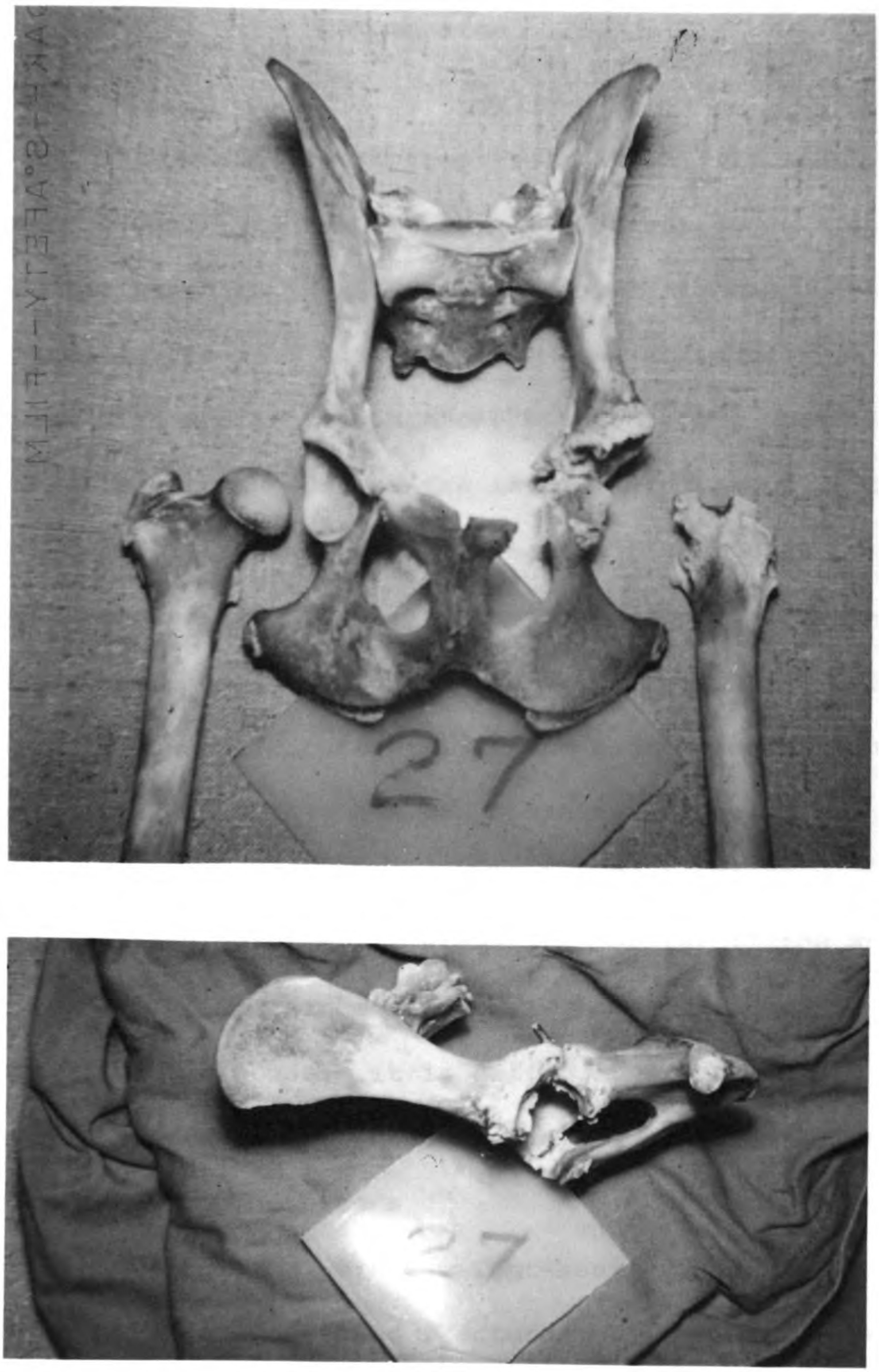


Figure 9.

Chapter V

Discussion

Although results were promising, it is felt that the method described is not the final answer to severe acetabular fracture in the dog. Good results can be anticipated in cases of unilateral central acetabular fracture with medial displacement of the femoral head if the ilial shaft and body of the ischium are intact on the affected side; if the dog is six months old or older and is a cocker-sized dog or larger and if the circulation to the femoral head is not severly disrupted. Poor results can be anticipated (1) if the acetabular fracture is bilateral and both sides are operated at one time; (2) if either ilial shaft or ischial body is fractured, thus preventing coxofemoral stability; or (3) if the animal is very young, since the towel clamps will tear through immature bones. It is difficult to obtain satisfactory exposure and reduction in toy dogs, obese animals or chondrodystrophic breeds.

Fractures of the dorsal weight-bearing surface of the acetabular crescent and fractures of the ilial aspect of the acetabulum are most readily managed by the method described. Fractures of the posterior lip of the acetabulum are most difficult to reduce and fix because of the presence of the internal obturator muscle and ischial curvature at this point.

Investigation and modification of the Roger Anderson splint was not pursued because of its cumbersome nature, difficulty of sterilization and impracticality for use by practitioners.

The turnbuckle assembly, although not mechanically suited for the management of acetabular fractures, may be of some help in reducing overriding fractures of the ilial shaft or in sacroiliac separations.

The author became disenchanted with external fixation using Kirschner and Tower equipment because of the amount of time necessary to obtain an anatomical reduction, the increased necessity of attentive aftercare and the fact that the pins, even if well placed, soon lost their stabilizing influence when pressure necrosis of the pin-holes loosened the assemblies. Bone screws are better adapted to the fixation of pelvic fractures than bone pins because of greater grasping power and less of a tendency to loosen.

Bone plates are difficult to shape to the irregular surface of the bony pelvis. An inert metal strip which could be molded to the contour of the pelvis across fracture sites and secured with bone screws would be useful in the open reduction of certain pelvic fractures.

Simple hand corkscrews when screwed into cancellous bone provide an effective means of manipulating bone fragments. This should be particularly effective in large animal orthopedics where fragments are large and cannot be easily moved with bone grasping forceps.

The author prefers the dorsal surgical approach to the coxofemoral joint as described by Brown because of the adequate exposure of the area, minimal hemorrhage and the versatility the approach offers for treatment of a variety of conditions.

The dorsal approach to the ilium described by Cawley and Archibald (1955) is only practical when used for fractures very high on the ilial shaft. The ventral approach of Rieger (1956) is limited to rather rare fractures of the anteroventral acetabular lip and wiring of these fragments does not result in effective stability. The perineal approach described in Chapter III may be of some value in the pinning of the ischial body but exposure of the ischium is obscured by the internal obturator muscle.

The pelvis is well protected by muscle, fat and fascia. This probably accounts for the tremendous force, such as is experienced in automobile accidents, required to disrupt the pelvis and the fact that pelvic fractures are seldom compound. The pelvic musculature is probably in a spastic state following fracture and this could be the reason for the lack of crepitus in these cases. Muscle spasm imparts a relative stability to bone fragments and this stability probably accounts for much of the success following conservative treatment of pelvic fractures. The author suggests the employment of rectal palpation of the pelvis as a routine procedure in all automobile accident cases. Since the pubic bones are the weakest portion of the bony pelvis and are usually broken when pelvic displacement occurs, rectal palpation of the pelvis particularly the pubes can quickly determine the presence or absence of pelvic disruption.

It is the author's opinion that further research in the area of open reduction and internal fixation of pelvic fractures in the dog would be rewarding. Further use and development of bone screws, small threaded bone pins and modification of the Hagie* and Knowles* pins would probably be the most fruitful approach.

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*Orthopedic Equipment Co., Bourbon, Indiana

Chapter VI

Conclusions

1. Severe impact, such as being struck by an automobile, is necessary to fracture the canine bony pelvis. When enough force is applied to the pelvis to cause disruption, the pubic bones are nearly always fractured. Pubic fractures can be ascertained by rectal palpation.

2. The extent of a pelvic fracture cannot be determined by observation of a dog's ability to stand and walk.

3. Both ventro-dorsal and lateral radiographs are necessary for accurate evaluation of pelvic fractures and for the choice of treatment method.

4. Some advantages of internal fixation of severe pelvic fractures as opposed to external fixation are: (a) more precise anatomical reduction, (b) lower cost of equipment and (c) ease of postoperative care.

5. Bone screws or screw-like pins have a greater usefulness in the fixation of pelvic fractures than do non-threaded bone pins.

6. Rather severe unilateral fractures of the dorsal acetabular crescent in the dog can be repaired by open reduction and internal fixation. The fracture site is exposed by Brown's (1953) dorsal surgical approach to

the coxofemoral joint; the fracture is reduced mechanically and fixed with a single bone screw. This method seems to be limited to unilateral fractures of the dorsal and anterodorsal acetabular crescent. Dorso-ventral and lateral radiographs of pelvic fractures should be carefully studied with a skeletal pelvis in hand to determine whether or not this method of treatment is applicable.

7. Avascular necrosis of the femoral head because of disruption of its blood supply may be encountered in this type of fracture or after this method of treatment. A moderate to marked fibrosis of the coxofemoral joint capsule may also be expected as a postoperative result.

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