ANATOMICAL AND SURGICAL CONSIDERATIONS OF THE OS PENIS OF THE DOG AS RELATED TO CORRECTION OF URETHRAL OBSTRUCTION BY CALCULI

by

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INTRODUCTION

An improved surgical technique for the relief of obstructive recurring urethral calculi in the male dog has long been needed. The methods that have been used have frequently interfered with the normal physiological function of the penis.

A peculiarity of the male dog penis was the presence of a visceral skeletal structure termed the os penis. This bone, situated within the male organ, made the male dog very vulnerable to obstructive urethral conditions. Obstructive urethral calculi did not usually affect the female since the urethra was very dilatable and relatively short. The male dog with a relatively long urethra and the presence of an os penis presented many serious problems.

Urethrotomy caudal to the os penis was the previous surgical treatment. An incision was made through the body of the penis and into the lumen of the urethra to remove the obstructive calculus. This method had proven satisfactory on the initial occurrence but complications occurred on succeeding recurrences. Subsequent obstructions stimulated the formation of a urethral stricture at the site of incision. Further surgical incisions aggravated the existing stricture. In many of these cases a permanent urethral fistula had to be established to allow the free flow of urine in the act of micturition. Dogs with a permanent urethral fistula micturated abnormally. A valuable breeding dog would be of no value. The method proposed in this paper would help alleviate this situation in that the genitalia

would be intact for the act of copulation.

This study was primarily concerned with the anatomical and surgical considerations for correction of urethral calculi blockage. Since blockage or obstruction by urethral calculi was of an acute nature, immediate corrective intervention was indicated for temporary or permanent relief. It was hoped that this study would provide a method for the immediate relief and the prevention of a recurrence of obstructive calculi caudal to and within the groove of the os penis.

The objective was to provide a surgical technique that would be applicable for the correction of urethral calculi, without intervening into the lumen of the urethra, by removing a portion of the os penis. This procedure was developed to allow the passage of future potential obstructive urethral calculi.

MATERIALS AND METHODS

The method of study was divided into three phases for organization and clarity. The first phase dealt primarily with gross anatomical studies of the penis and associated structures. The second phase was concerned with surgical technique and observations. The third phase dealt with anatomical evaluation of the involved surgical area.

In the first phase twenty-five male dogs were used in the investigation. The ages of specimens varied from a few months to several years. Most dogs were of mixed breeds. All dogs seemed normal in areas related to this project. None had been castrated so that the penis and associated structures were

developed under the influence of the male hormone.

The dogs were anesthetized with sodium pentobarbital. The common carotid artery was isolated and cannulated and the dogs exsanguinated by their own heart action. The entire dog was then gravity embalmed with an aqueous solution containing ten per cent formaldehyde, two and one-half per cent glycerine and enough acetic acid to render the solution acid. Following preservation, the arterial system was filled with latex. After the latex had solidified, the penis and surrounding prepuce was removed from the animal for study. The penis was incised so the angioarchitecture, os penis, body of the penis, glans penis and prepuce could be dissected in an organized manner.

Twenty male dogs were used in the second phase of this project. All dogs seemed to be healthy and normal as related to this project. The dogs were selected at random in regard to age, size, and breed. All dogs were given the opportunity to urinate prior to surgery.

Dogs numbered one, two, three, four, five, and six were anesthetized with sodium pentobarbital in combination with mephenesin, a muscle relaxant. Difficulty was encountered with respiratory distress in some dogs so that only sodium pentobarbital was used in the remaining fourteen cases.

The dogs were then placed in dorsal recumbency and secured firmly on the surgical table. In all cases, the surgical site prepared extended from the umbilicus to just caudal to the scrotum. The width of the prepared surgical site extended two

inches from either side of the midline. Preparation of the skin and external prepuce for aseptic surgery was routine in every case. The hair was clipped with a surgical clipper, the skin and prepuce was scrubbed with a neutral pH reacting detergent (Phisohex), the skin defatted with commerical ether, and an alcoholic quaternary ammonium compound pack applied to the surgical site after the preputial cavity was prepared for surgery. The antiseptic pack remained in place ten minutes prior to surgery.

Preparation of Internal Prepuce

In dogs numbered one and two the preputial cavity was prepared by irrigating the cavity with a seventy per cent alcoholic quaternary ammonium compound and a liquid soap preparation. Some inflammation of the preputial cavity occurred in dog one. The preputial cavity and glans penis of dog number two were covered by ayyellow exudate on the third and fourth postoperative days. This condition was discussed in the observations. The method of preparation of the preputial cavity was varied to avoid a recurrence of this condition. In all remaining cases the preputial cavity was prepared using a neutral detergent with antiseptic properties. The preputial cavity was irrigated with three changes of a fifty per cent Phisohex and water solution. The last change was left in the preputial cavity. Following the last preputial cavity irrigation the antiseptic pack was applied to the surgical site.

The surgeon prepared himself for aseptic surgery, that is,

scrub, sterile gloves, cap, gown, and face mask. The operative site was then draped with sterile shrouds.

Skin Incision

The initial skin incision was the same in dogs one and two. The incision extended from the prèputial orifice to one-half inch caudal to the level of the os penis on the ventral midline. Incising from the preputial orifice caudally allowed the glans penis to be entirely exposed within the preputial cavity. This method proved unsatisfactory and not used in any of the succeeding cases. In the remaining cases the initial skin incision was begun one-half to three-quarters of an inch caudal to the prèputial orifice, depending upon the size of the dog. In all cases the caudal extent of the skin incision extended caudal to the level of the os penis and cranial to the base of the scrotum (Plate I). It was important to make the skin incision directly on the ventral midline to allow for any postoperative drainage. To help make the skin incision in the external prepuce, a grooved director was placed within the preputial cavity to act as a guide (Plate I). The grooved director was then removed when making the skin incision over the body of the penis. The incision through the external prepuce extended to the parietal layer of the internal prepuce. The incision over the body of the penis extended to the penile fascia covering the retractor penis muscle (Plate I). All subcutaneous vessels were ligated to control hemorrhage from the skin incision.

Incision of Parietal Layer of Internal Prepuce

Following the skin incision the parietal layer of the internal prepuce was incised with scissors using the grooved director as a guide. This incision extended to the fornix preputialis. At this point the glans penis was displaced through the incision in the prepuce. A sterile drape was then placed beneath the glans penis to separate it from the preputial cavity and a urethral catheter was then placed within the urethra (Plate IV). It was important to insert the catheter just beyond the caudal extent of the os penis. It was undesirable to insert the catheter into the urinary bladder since urine may flow from the catheter onto the surgical field.

Incision Through Penile Fascia

The next procedure in all cases was to incise through the fascia surrounding the ventral aspect of the body of the penis to the retractor penis muscle. It was important not to incise or otherwise disrupt the attachment of the retractor penis muscle from the fornix preputialis. The retractor penis muscle was reflected to the opposite side of the penis than that which was being worked upon. This exposed the corpus cavernosum urethrae located within the ventral aspect of the body of the penis (Plate III).

Exposure of the Os Penis

In dog number five the following procedure was initiated.

First, the corpus cavernosum urethrae was bluntly dissected from the tunica albuginea on one side. Secondly, the pars longa glandis was incised on the same side using a pair of scissors. This incision extended from the caudal extent of the pars longa glandis to approximately one-half to three-quarters of an inch from the urethral orifice or just cranial to the cranial extent of the urethral groove of the os penis. The pars longa glandis was then separated from the lateral aspect of the os penis as far caudal as the bulbus glandis. Care was taken to avoid cutting the deep vein of the glans that drains erectile blood from the pars longa glandis to the bulbus glandis. Care also was taken to avoid cutting the bulbus glandis. Thirdly, the corpus cavernosum urethrae was then bluntly dissected from the cranial extent of the urethral groove of the os penis as far caudalas the erectile shunts with the bulbus glandis. Finally, the erectile shunts between the corpus cavernosum urethrae and the bulbus glandis were incised. The bulbus glandis was then very carefully dissected from the "saddle" of the os penis. This was a very delicate procedure as the ventral erectile shunt of the bulbus glandis could not be disrupted. Also, the deep branch of the dorsal artery of the penis was situated between the bulbus glandis and the lateral aspect of the os penis.

In dogs numbered one, two, three, four, six, seven, eight, eleven, twelve, and thirteen the following procedure was followed in exposing the os penis. First, the pars longa glandis was incised with scissors from the fornix preputialis to one-half to three-quarters of an inch from the preputial orifice depend-

ing upon the cranial extent of the lateral wall of the urethral groove of the os penis. The pars longa glandis was reflected upward in order to partially separate it from the lateral aspect of the os penis and away from the bulbus glandis. Care was exercised to avoid incising the deep vein of the glans which connected the pars longa glandis to the bulbus glandis. The fascia beneath the retractor penis muscle was then cut to expose the corpus cavernosum urethrae located beneath the body of the penis. The corpus cavernosum urethrae was then bluntly dissected from the tunica albuginea, on the same side of which a part of the os penis was to be removed, and then dissected from the lateral wall of the urethral groove of the os penis cranial to the bulbus glandis. In dogs numbered eight, eleven, and thirteen the lumen of the urethra was accidently opened whn separating the corpus cavernosum urethrae from the lateral aspect of the urethral groove of the os penis. The connections or shunts between the corpus cavernosum urethrae were severed from the bulbus glandis only on the side to be removed. Finally, the bulbus glandis was very carefully dissected from the "saddle" of the os penis so the ventral erectile shunt of the bulbus glandis was not destroyed.

In dogs numbered nine, ten, and fourteen through twenty the following procedure was used to expose the wall of the os penis. The various parts of the erectile tissues were not incised separately as in previous cases. The retractor penis muscle was carefully dissected away from the ventral aspect of the corpus cavernosum urethrae. A pair of sharp pointed scissors

were used to penetrate into the corpus cavernosum urethrae as close to the tunica albuginea as possible (Plate III). The initial entrance into the erectile tissue was made caudal to the base of the os penis. The incision was then extended to just cranial to the cranial aspect of the urethral groove of the os penis (Plate IV). Extreme care was exercised to avoid cutting into the lumen of the urethra as hemorrhage may occur following urination for several days postsurgically. The only real precaution taken was to keep the cutting edge of the scissors as close to the inner wall of the os penis so that the lumen of the thin-walled urethra was not incised. From the fornix preputialis cranially, the corpus cavernosum urethrae and the pars longa glandis were incised simultaneously to just cranial to the lateral wall of the urethral groove (Plate IV). The pars longa glandis was retracted from the side of the portion of the os penis to be removed (Plate V). Next, the tightly adhering bulbus glandis was dissected from the "saddle" of the os penis on the side to be removed as was done in the previous cases (Plate V). The deep vein of the glans and the dorsal vein of the penis were avoided so that their severence would not interfere with the mechanism of erection.

Removal of Lateral Wall of Urethral Groove

In all cases the surgery had progressed to the point of exposing the lateral wall of the os penis that was to be removed. The next procedure was then to remove one lateral wall of the os penis. In about one-third of the cases the lateral

wall of the os penis was removed from caudal to cranial. In the remaining two-thirds of the cases the lateral wall of the os penis was removed from cranial to caudal.

When cutting the lateral wall of the os penis from caudal to cranial it was necessary to start the cut cranial to where the corpus cavernosum penis attached to the os penis, then return to this attachment and remove the remaining portion of bone along with some of the corpus cavernosum penis.

The cranial to caudal approach was better as it was more convenient for the surgeon. However, it was necessary for the surgeon to change sides of the operating table so that the side of the os penis to be removed was nearest to the surgeon. The cutting procedure began where the lateral wall of the os penis blended into the apex of the os penis (Plate VI). It was important that all of the lateral wall on one side be removed so that the urethral groove only had bone remaining on its dorsal and one lateral extent. Care was exercised in that the depth of the cutting instrument be maximal to insure removing the most of the lateral wall. The deep branch of the dorsal artery of the penis was very vulnerable to incision when the lateral wall was removed (Plate V). The lateral wall was best removed by removing one-quarter to three-eights inch sections at a time (Plate VII). The cut edge of the bone was left relatively smooth to promote rapid healing. It was extremely important that all of the caudal lateral wall of the os penis be removed as this was the first structure that caused obstruction. As the base of the os penis was truncated in shape and the corpus cavernosum

penis partially attached to the truncated portion, it was necessary to remove a part of the corpus cavernosum penis with the os penis (Plate VII). The incision to cut the tunica albuginea, which covered the corpus cavernosum penis, was made in such a manner that it extended slightly caudal from the truncated os penis so that the bone and erectile tissue could be removed together. Little hemorrhage was encountered when this erectile body was incised. The direction of the incision through the erectile tissue was directed downward and forward with the dog in the surgical position. There were no bone pieces left in the operative site. When the tunica albuginea was incised during the surgical procedure care was exercised to avoid cutting the dorsal vessels of the penis or its main branches as they lay along and dorsal to the body of the penis.

Hemostasis of Surgical Field

Control of surgical hemorrhage into the operative field presented a constant problem. It was estimated that in the initial cases hemorrhage increased the operative time by approximately fifty per cent. Various methods were devised to control hemorrhage in the early cases. In dogs numbered one, five, six, and seven a partial tourniquet, consisting of an Allis tissue forcep padded with gauze, was placed around the body of the penis in an attempt to reduce hemorrhage. This method did not work satisfactorily. In dogs numbered two, three, and four an assistant applied digital pressure to the dorsal artery of the penis but this method proved very tiring to the assistant. In

dogs numbered eight, nine, ten, and eleven hemorrhage was partially controlled by retracting the body of the penis from the abdominal wall, making an incision in the connective tissue between the body of the penis and the abdominal wall and placing a rubber tubing covered pair of Allis tissue forceps around the right and left dorsal vessels of the penis. This method proved satisfactory but cumbersome and was discarded. A method using a piece of latex tubing around the entire body of the penis, including the dorsal artery and vein of each side, was used in cases twelve and thirteen. In all remaining cases a piece of small diameter rubber catheter was placed around only the dorsal vessels of the penis (Plate II). This method proved to be the most satisfactory.

Following removal of all of the one lateral wall of the urethral groove of the os penis hemorrhage was controlled before closure of the incised tissues. This was necessary so that excessive clot formation did not occur within the enclosed tissues.

Closure of Incisions

Closure of the incised glans penis was performed in two different sequences. In a few cases it was sutured from caudal to cranial and the remaining cases it was sutured from cranial to caudal. The latter method proved the most satisfactory. Closure of the incision from cranial to caudal was performed in the following manner. Medium chromic 00 catgut was used in a continous suture. Extreme care was taken so that the cut edges

of the glans penis were brought into direct apposition and no overlapping of the tissues occurred (Plate VIII). It was also very important that the closure extended to the most caudal extent of the fornix preputialis (Plate VIII).

Closure of the incised penile fascia on the ventral aspect of the body of the penis was performed in the same manner in all cases. A continous suture using 00 medium chromic catgut was placed from the fornix preputialis to the caudal extent of the incision (Plate VIII). Care was taken to avoid placing sutures in the musculature of the retractor penis. Interrupted catgut sutures were placed in the subcutaneous tissue over the body of the penis.

Closure of the parietal layer of the internal prepuce was performed the same in all cases. A continous suture using 00 medium chromic catgut was started at the fornix preputialis and ended at the cranial extent of the incision. The suture was so placed that the cut edges of the parietal prepuce were turned into the preputial cavity.

In dogs numbered eight, eleven, and thirteen the lumen of the urethra was accidently opened when the corpus cavernosum urethrae was being dissected from the lateral wall of the os penis. In dog eight a section of the wall of the urethra one-half inch long and one-sixteenth inch wide was removed in the procedure. This incision was not closed and observations will be noted later. In dogs eleven and thirteen the lumen of the urethra was incised for a distance of one and one-quarter of an inch. The incision was closed using 0000 medium chromic

catgut.

Closure of the skin incision was performed the same in all animals. Simple interrupted non-absorbable sutures were placed the entire length of the skin incision.

Penicillin and dihydrostreptomycin were administered intramuscularly following surgery and for two postoperative days. A urethral catheter was not used in any cases postoperatively.

At the termination of the postoperative periods all dogs were euthanized, embalmed, and injected with latex. The penis and prepuce were removed and further study was made of the post-surgical healing by gross dissection.

REVIEW OF LITERATURE

The literature review was conducted in two major general areas. The anatomy of the penis and associated structures were reviewed. The surgical work on the penis was reviewed. Most of the volume of literature reviewed pertained to composition of urethral calculi, theories on formation of calculi, medical treatment of calculi, recurrence of urethral calculi, age incidence in calculi, and finally standard methods on the performance of external urethrotomy. The literature reviewed did not reveal any surgery that pertained to the specific operative technique used in this study.

Bowers (1944), Brumley (1943), Campbell (1927), Fleming (1902), Fuller (1939), Garbutt (1938), Mayer, Lacroix, and Hoskins (1957), Milks and Muldoon (1917), Muller and Glass (1923), O'Connor (1912), O'Connor (1952), Peabody (1890),

Springer (1910), White (1902), and Woodruff (1912) reported and described cases in which the lumen of the urethra of the male dog was obstructed by calculi. Each author performed the external urethrotomy caudal to the os penis.

Brodey (1955), Bruce (1956), Krobbe (1949), Stephenson (1939), and White (1944) reported formation of calculi, age incidence in calculi, chemical composition of calculi, and that surgical intervention with formation of a permanent urethral fistula was usually necessary.

Barchfeld (1956) clamped the urethra and surrounding corpus cavernosum urethrae to control hemorrhage at the incision site when the external urethrotomy was performed for the removal of urethral calculi.

Bradley (1959) described the parts of the penis and prepuce, but limited detailed discussion of the os penis and terminal branches of the dorsal artery of the penis. The collateral circulation of the penis was not described.

Brodey (1954) described a urethral calculus in a four month cocker spaniel for which a urethrotomy was performed. The occurrence of this condition in an animal of this age was unusual but not rare.

Chauveau (1901) described the anatomy of the os penis and the erectile tissue of the penis. Christensen (1954) gave the most accurate and complete description of the angioarchitecture of the dog penis. Special emphasis was placed upon collateral arterial circulation, venous connections and the mechanism of erection of the penis.

Cozzens (1932) described urethrotomy and urethroplasty as operative techniques for the relief of urethremphraxis and urethrostenosis caused by calculi lodging in the urethra and the conditions that may follow operations for the removal of calculi.

Deysach (1939) gave a partial description of the arterial blood supply to the dog penis.

Ellenberger and Baum (1943) gave a limited description of the penis and prepuce, but only mentioned the blood supply and did not include any of the collateral circulatory channels.

Fish (1906) described a dog with urethral calculi. This case was the only case reviewed in which the urethrotomy performed was done from the lateral aspect and not the routine ventral approach. Several weeks later a recurrence of the calculus occurred and another urethrotomy was performed. Each time following the surgery swelling of the testicles and scrotum occurred.

Harding and Sumner (1955) described a case in which recurrence of obstructive urethral calculi occurred three times. A third operation was deemed impracticable and unwise since two previous urethrotomies had been performed in the same area just caudal to the os penis.

Hill (1884) said that surgery was not indicated in cases of urethral obstruction by calculi. His treatment consisted of passing the catheter for relief.

McCunn (1947), Markowitz, Archibald and Downie (1959), and Morris et al. (1935) described the external urethrotomy pro-

cedure. Morris et al. (1935) stated that they had seen and removed surgically the first cystine stone in a living dog.

Miller (1952) described the os penis and divided it into three parts. However, no mention was made of the relationship of the erectile tissue to the parts of the os penis. Nothing was mentioned of collateral arterial circulation between the various arteries of the penis and anastomotic branches of the dorsal artery of the penis. He made the statement that the erectile tissue of the glans penis was separate from the corpus cavernosum urethrae. This statement was not correct. The prepuce was only mentioned and the relationships of the prepuce were not mentioned.

Kent (1954) described some of the heterotropic skeletal bones of vertebrates. Synonyms for os penis included the terms os priapi and baculum. He said this bone was found in the penis of many mammals, including bats, rodents, carnivores, insectivores, whales, and primates except man. Ruth (1934) made a study of the development of bone as found in the os penis of the white rat.

Nickel, Schummer, and Seiferle (1960) and Sisson and Grossman (1953) gave a fairly complete description of the penis and prepuce. The arterial and venous vessels were not adequately described. The os penis was described as being the cranial part of the corpus cavernosum penis but was only briefly considered. The relationships of the erectile tissue to the os penis was not considered.

Steel (1888) described the external urethrotomy technique.

He also described the anatomy of the dog penis with emphasis on the erectile bodies. He stated that the pars longa glandis was an expansion of the erectile tissue of the urethra. This statement was not correct.

Pollock (1955) described a case of cystinuria in a dog. Included in this report were some of the characteristics of cystine stones, methods of surgical intervention, and post-operative care.

Reid and Hobday (1909) reported on a case in a puppy of a urethral obstruction blocking the urethra at the urethral orifice.

OBSERVATIONS

The observations were made in several phases. The first phase was concerned with the gross anatomy of those parts of the normal dog genitalia that related to this study. The second phase was concerned with the postoperative observations of the live surgical cases. The third phase was concerned with gross dissection of the postsurgical specimen.

Prepuce

The prepuce was a double tubular fold of epithelium surrounding and enclosing the cranial portion of the penis (glans penis). The preputial cavity was largely potential as the glans penis occupied most of the cavity. The preputial cavity communicated cranially with the outside through a slit-

like opening termed the preputial orifice. The preputial orifice was directed slightly downward and backward and was surrounded by thick tufts of hair.

The prepuce was composed of two major layers of integument, the external layer and the internal layer. The external layer was ordinary skin containing hair, sebaceous glands and sweat glands. The cranial portion of the external layer was relatively thick due to an increased amount of subcutaneous fat and loose connective tissue. Within the external layer surrounding the preputial orifice was the preputial muscle which was a flattened band of skeletal muscle. This muscle had an action of preputial protraction.

The internal layer of the prepuce was divided, the parietal layer and the visceral (penile) layer. Both layers were hairless and relatively thin. The parietal layer was directly continous with the external layer of prepuce within the preputial cavity just caudal and within the preputial orifice. The line of reflection from the parietal layer to the visceral layer of internal prepuce was very abrupt and was termed the fornix preputialis. The fornix preputialis was located around the cranial one-half of the bulbus glandis. The visceral or penile layer of the internal prepuce was very thin and hairless. It was very firmly attached to the pars longa glandis and had a weak attachment to the bulbus glandis. It was therefore easier to remove the visceral layer from the bulbus glandis as there was a greater amount of loose connective tissue present in this area. The parietal layer of the internal prepuce was relatively loosely

attached to the external layer of the prepuce. Both internal layers were covered by many elevated lymph nodules. The lymph nodules were limited to the caudal aspect of the preputial cavity.

The prepuce had a dual blood supply that was derived from the external pudendal artery and the preputial branch of the dorsal artery of the penis.

Surgical Anatomy of the Penis

The penis was divided into three major divisions: the root, body, and the cranial free extremity (glans penis).

Penile Fascia

A loose irregular connective tissue fascia surrounded the body of the penis. The fascia completely surrounded the body of the penis and contained the collateral anastomosing branches between the branches of the arteries of the penis. This fascia enclosed the dorsal vessels of the penis and the branches of the internal pudendal nerve on the body of the penis. When the body of the penis was retracted from the ventral abdominal wall a median septum of connective tissue was present connecting the dorsum of the penis to the subcutaneous fascia of the abdominal wall. A considerable amount of penile fascia was found separating the bulbus glandis from the pars longa glandis.

Erectile Tissue of the Penis

The corpus cavernosum urethrae (spongiosum) surrounded the

urethra and was loosely attached to the inner surface of the urethral groove within the os penis and may provide a partial blood supply to the os penis. The corpus cavernosum urethrae was enclosed by a portion of the os penis from the cranial portion of the body of the penis to the cranial one-third of the glans penis area. It had several erectile anastomotic connections that supplied the bulbus glandis with erectile blood. It had its main blood supply from the artery of the urethral bulb. It also had anastomotic branches from the deep artery of the penis and the dorsal artery of the penis.

The corpus cavernosum penis originated as paired cavernous bodies from the ischial tuberosities and was directed cranially to and as far as the caudal aspect of the os penis. Here the corpus cavernosum penis transformed into and was attached to the truncated portion of the os penis. The corpus cavernosum penis was completely surrounded by the tunica albuginea with a vertical septum separating the right and left parts. There was relatively little erectile spaces in this body as it was traversed by many fibrous bands and its walls were thick.

The glans penis was the most cranial division of the penis. It consisted of a rounded caudal enlargement, the bulbus glandis and a longer cylinderical cranial part, the pars longa glandis. The bulbus glandis was capable of considerable dilation due to the large amount of erectile or cavernosus tissue located within it. Its dilation was not limited by a fibrous capsule as was the corpus cavernosum penis. Most of its tissue was located on the dorsal and lateral aspect of the os penis at the junction of the

os penis caudal and middle thirds. The slight depression on the os penis that contained the bulbus glandis was termed the "saddle". There was some erectile tissue of the bulbus glandis on the ventral aspect of the os penis. The bulbus glandis had a very firm attachment to the dorsal and lateral aspect of the os penis. The connective tissue between the bulbus glandis and the os penis was very thin, this making it extremely difficult to separate the two without entering the erectile spaces of the bulbus glandis. The deep branch of the dorsal artery of the penis was located within this attachment. The dorsal vein of the penis originated from the caudo-medial aspect of the bulbus glandis and thus drained the erectile spaces of the glans penis. A rather thick loose connective tissue layer separated the bulbus glandis from the pars longa glandis. This same layer extended cranially separating the pars longa glandis from the os penis and the corpus cavernosum urethrae. It furnished a rather loose attachment for the pars longa glandis to the deeper structures which made it rather easy to separate the pars longa glandis from the os penis. This connective tissue was a part of the penile fascia.

The pars longa glandis was composed of primarily erectile tissue. It did not undergo the extreme dilation as seen in the bulbus glandis during erection. The caudal portion of the pars longa glandis surrounded a portion of the cranial part of the bulbus glandis. Cranially, the pars longa glandis completely surrounded the os penis, corpus cavernosum urethrae and urethra. There was no septum separating the right and left sides. It

received its blood supply from the artery of the urethral bulb, branches of the preputial branch of the dorsal artery of the penis, branches of the superficial branch of the dorsal artery of the penis, the deep branch of the dorsal artery of the penis and branches of the external pudendal artery. The urethral orifice was located in the cranial ventral aspect of the pars longa glandis directed downward and forward.

Blood Supply of the Penis

The internal pudendal arteries and branches from the external pudendal arteries that anastomosed with the preputial branches of the dorsal arteries of the penis supplied the penis and prepuce.

The artery of the urethral bulb was continued cranially in the corpus cavernosum urethrae to the cranial aspect of the glans penis. It supplied the corpus cavernosum urethrae, indirectly the bulbus glandis which received its venous erectile blood from the corpus cavernosum urethrae by way of several connecting branches or shunts, the extrapelvic urethra, and the pars longa glandis. This artery anastomosed with the deep artery of the penis and the dorsal artery of the penis.

The deep artery of the penis entered the corpus cavernosum penis which it supplied. It may also supply the os penis as the penile bone was considered a modification of the cranial part of the corpus cavernosum penis.

The dorsal artery of the penis lay on the dorsum of the penis along with its satellite vein and the internal pudendal

nerve. The dorsal artery lays slightly lateral and ventral to the vein. The dorsal vessels were enclosed within the penile fascia. Just caudal to the bulbus glandis, the dorsal artery was directed ventrally and cranially and terminated by dividing into three main branches. The superficial branch was directed ventrally and cranially just under the visceral prepuce and extended along the ventral part of the glans penis as far cranial as the urethral opening. The preputial branch ran craniad and dorsad to the fornix preputialis where it gave branches to the dorsal visceral prepuce and other branches that were distributed to the area of the ventral abdominal fascia. The latter branches anastomosed with branches from the external pudendal artery. The deep branch of the dorsal artery perforated the tunica albuginea. It then passed cranially, deep to the bulbus glandis, along the dorso-lateral aspect of the os penis. In this area there was very little connective tissue separating the bulbus glandis from the os penis. The artery passed forward beneath the bulbus glandis and supplied a part of the pars longa glandis.

The dorsal vein of the penis arose from the caudal aspect of the bulbus glandis, made a slight S-shaped curve towards the dorsal surface of the body of the penis and was then directed caudally along the body towards the ischial arch. The deep vein of the glans penis drained blood from the pars longa glandis to the bulbus glandis. It was found on the dorso-lateral aspect of the os penis closely associated with the deep branch of the dorsal artery of the penis cranial to the bulbus glandis. The

superficial vein of the glans penis arose from the dorsal deep aspect of the pars longa glandis and drained into the external pudendal vein.

Os Penis

The os penis has also been termed the os priapri and the baculum. The os penis may be considered to be an ossification of the cranial part of the corpus cavernosum penis. Its purpose or function could only be speculated. Probably without question its primary function was concerned with the act of copulation. Probably, because of the delayed process of erection of the glans penis, a structure of this sort was necessary to insert the penis into the female genital tract with a reasonable amount of rigidity prior to the maximum enlargement of the glans penis. Its mere presence made it vulnerable to injury. The firmness made the penis more susceptable to trauma as there was less tissue mobility. A number of conflicting theories have been advanced as to the development of this bone. The presence of the os penis made necessary an anatomical study so that other phases like surgical and physiological procedures may be better understood and undertaken with confidence.

The os penis was divided into four arbitrary sections in the intact penis. From caudal to cranial it consisted of the base, body, apex and cartilage.

The base was considered to be that part of the bone that provided attachment for the tunica albuginea of the corpus

cavernosum penis. Its lateral aspect was roughened and pitted to provide a strong attachment for the tunica albuginea. The lateral area of attachment was quite extensive and the cranial extent of attachment was directed downward and forward onto the base of the os penis. The caudal extent of the base was truncated. Its ventral surface inclined slightly dorsal and caudad so that as the urethra passed through the urethral groove the ventral border crossed the urethra at an angle. This angle varied from dog to dog but was always present. The urethral groove began at the caudal extent of the base. The dorsal surface of the base was bilaterally convex and usually smoother than the lateral aspect.

The body of the os penis was the longest of the four parts. Throughout most of its length the body was triangular in cross section. It was the cranial continuation of the base of the os penis. Its ventral surface was grooved to enclose the urethra and the corpus cavernosum urethrae on three sides. The dorsal surface presented on its caudal aspect a depression over and around which was situated the bulbus glandis. The depression was termed the "saddle" of the os penis. The dorsal border of the body was considerably narrower than the dorsum of the base. The lateral sides of the body were biconcave throughout their entire length. At the junction of the cranial one-third and the middle-third of the lateral sides was an enlarged roughened area which provided attachment for some of the erectile tissue of the bulbus glandis. A shallow groove was present between the

roughened area and the dorsal border of the body. The deep vein of the glans and the deep branch of the dorsal artery of the penis passed through this groove. The ventral part of the lateral sides, in some instances, was directed medially so that it nearly converted the three-sided urethral groove into an enclosed tube.

The apex was the cranial continuation of the body. The line of demarcation between the apex and body was at the termination of the urethral groove. The dorsal and lateral surfaces were smooth and convex while the urethral surface was nearly flat. The urethral surface of the apex did not bear the urethral groove. The termination of the urethral groove was very gradual and blended into the lateral ventral aspect of the apex. The cranial end of the apex may be slightly enlarged and have a conical projection extending from it.

The cartilage attaching to the cranial end of the apex was hyaline cartilage in the young dog but as the dog matured there was a gradual change from hyaline to fibrocartilage. The cartilage usually bent ventral and cranially from the apex of the os penis to parallel the direction of the terminal portion of the urethra and corpus cavernosum urethrae. The cartilage, the apex of the os penis, and a part of the body of the os penis were surrounded by penile fascia that extended forward from between the bulbus glandis and the pars longa glandis.

The presence of the urethral groove was the anatomical cause of obstructive urethral calculi. This groove extended from the caudal aspect of the base of the os penis to the junc-

tion of the body and apex on the ventral surface of the os penis. The caudal part of the urethral groove was relatively shallow but as the groove progressed cranially it became deeper and narrower at the junction of the base and body. From this point the depth of the groove remained the same but became slightly wider throughout the length of the body. At the junction of the apex and body the groove disappeared completely. The urethral groove was bounded on three sides by bone, that is, dorsally and laterally. In several instances the lateral boundries were directed medially so as to partially convert the urethral groove into a tube-like canal.

Postsurgical Observations of Dogs

All dogs were observed postsurgically. The number of postsurgical observation days varied from one day to one hundred and forty-five days.

Case One. First Day. There was no hemorrhage from the incision site and the dog urinated without difficulty. The dog was alert and apparently not experiencing any observable pain. There was an absence of preputial discharge.

Second to Fourth Day. The dog urinated normally except on the fourth day when a little difficulty in the force of urination was observed. This was considered of little significance.

Fifth Day. The dog urinated normally. The prepuce was manually retracted and the glans penis was found to be normal in every respect.

Sixth to Twenty-Third Days. The dog seemed normal in every

respect. The skin sutures were removed on the thirteenth day. The dog was euthanized on the last postoperative day.

Case Two. First Day. The dog was not alert and still partially under the influence of the anesthetic. There was no observable hemorrhage from the incision site. The act of urination was normal. Penicillin ointment was instilled into the preputial cavity.

Third Day. The dog did not appear normal and alert and urinated with some difficulty. A yellow purulent discharge was present and attached to the inner wall of the preputial cavity. The cavity was cleansed and a penicillin ointment was instilled into the preputial cavity. Some hemorrhage occurred from the incision site when the ointment was instilled into the preputial cavity. This may have been due to the fact the dog had a slight erection. Penicillin and dihydrostreptomycin were administered intramuscularly.

Fourth Day. The dog could not urinate so the dog was anesthetized and examined. A rough denuded slough area of the skin of the lateral abdominal wall, scrotum, and prepuce was observed. A fibro-purulent material closed the preputial orifice. The glans penis was found to have a considerable amount of fibrinous material adhering to it and the glans penis had a very pale color. The parietal layer of the internal prepuce was very fibrinous. It was noted that the tongue of the dog was also irritated, probably due to licking of the surgical area. It was believed that there was an epithelial sensitivity to either the soap or the antiseptic solutions used in preparing the area for

surgery. The dog was euthanized. The os penis was removed and macerated to observe the amount of bone removed surgically.

Case Three. First to Fifteenth Days. The dog urinated normally and appeared normal in every respect. The skin sutures were removed on the eight postoperative day.

Case Four. First Day. Some hemorrhage was observed from the incision site and this was due to movement of the surgical area at the time of examination. The dog urinated in a normal manner.

Second to Fourteenth Days. There was no hemorrhage from the incision site. The dog urinated in a normal manner. The skin sutures were removed on the ninth postoperative day.

Case Five. First to Thirty-Third Days. The dog urinated in a normal manner on each day examined. There was an absence of any hemorrhage from the incision site. The skin sutures were removed on the eleventh postoperative day.

Case Six. Operative Day. Approximately three hours postoperatively the dog was given Metrazol to help facilitate recovery from the anesthetic. Normal respiration and heart action were present. Twelve hours postoperatively the dog was not making a rapid recovery but normal breathing and heart sounds were present. Eight hours later the dog was found dead in its cage. A necropsy was performed to determine the cause of death. The lungs were congested with a mucoid-like fluid tinged with blood. The pleural cavity contained a serosanguineous fluid. There were some endocardial hemorrhages, which may have been agonal changes. A slight hyperemia of the tracheal lining was

noted. The surgical site was examined and found to be free of any surgical abnormalities. The os penis was removed and macerated to observe the degree of bone removed surgically.

Case Seven. First Day. The dog urinated in a normal manner but hemorrhaged from the preputial cavity at the termination of the act of urination. Five cubic centimeters of Klot was administered. The dog was placed in its cage and not exercised.

Third Day. The dog was permitted to exercise and following urination hemorrhage occurred from the preputial cavity. This was thought to be due to the development of a partial erection. The patient was returned to its cage without further treatment.

Fourth to Ninth Days. The dog urinated with no subsequent hemorrhage.

Tenth Day. The skin sutures were removed. A small area of the skin incision in the parietal prepuce had not healed completely. The incision edges were then freshened and resutured.

Eleventh to Thirty-Eighth Days. The dog urinated normally and had no further complications.

Case Eight. First Day. The patient urinated without difficulty but passed blood after urination. This hemorrhage was thought to originate from the incision in the urethra which was accidently opened during surgery. Four cubic centimeters of Klot was administered.

Second to Forty-Ninth Days. The dog was apparently normal and urinated in a normal manner without passing blood. The skin

sutures were removed on the fourteenth day.

Case Nine. First Day. The dog did not urinate.

Second to Twenty-Eighth Days. The dog was normal in every respect and urinated without difficulty. The skin sutures were removed on the eight postoperative day.

Case Ten. First to Sixteenth Days. The dog was normal and urinated without difficulty. The skin sutures were removed on the sixth day.

Case Eleven. First Day. The dog urinated in a normal manner.

Third and Fourth Days. Hemorrhage occurred from the preputial cavity following urination. The hemorrhage stopped when the dog was returned to its cage.

Fifth to One Hundred and Forty-Five Days. The patient was entirely normal in every respect. The skin sutures were removed on the tenth postoperative day.

Case Twelve. First and Second Days. The dog urinated in a normal manner with no hemorrhage.

Third Day. The dog urinated without difficulty but the force of urination was weak. A scrotal irritation developed due to the dog licking the surgical area. It was dressed with a topical anesthetic creme.

Fifth to Twenty-First Days. The scrotal condition cleared. The dog urinated in a normal manner. The skin sutures were removed on the seventh day.

Case Thirteen. First Day. The dog had little difficulty in urination. Hemorrhaged from the preputial orifice following

urination because the lumen of the urethra had been accidently incised during the surgical procedure. The dog was confined to its cage. Parenteral coagulants were not administered. Antibiotics were not administered to this patient.

Second Day. The dog urinated in the normal manner but again hemorrhaged from the urethra following urination. Parenteral coagulants were not given. The dog was not exercised.

Third to Forty-Third Days. The dog urinated in a normal manner. The skin sutures were removed on the ninth day.

Case Fourteen. First Day. Antibiotics were not given to this patient. A normal act of urination was evident.

Second to Forty-First Days. The dog urinated in a normal manner. A severe scrotal irritation developed on the third day and was treated with a topical anesthetic creme. The skin sutures were removed on the tenth day.

Case Fifteen. First Day. The dog was taken out to urinate and appeared alert and normal. The dog started to urinate and began passing whole blood. During the act of urination the dog collapsed and stopped breathing. Artificial respiration was begun and before any respiratory or cardiac stimulants could be administered the dog died. A necropsy was performed two hours after death in an attempt to determine the cause of death. An embolus was initially suggested as such a sudden cause of death in either the coronary circulation or to a portion of the brain.

Observations found at necropsy revealed the following facts. Some stomach content covered by a mucoid-like material was found in the trachea and also in the main bronchi. The stomach was

nearly full of ingesta. The kidneys were slightly swollen. Some petechiation of the mucosa of the urinary bladder was observed. The tonsils were swollen and slightly hyperemic. The surgical area appeared normal. The os penis was removed and macerated to observe the degree of removal of the lateral wall by the surgical procedure.

Case Sixteen. First to Seventh Days. The dog appeared and acted entirely normal. There was a normal act of urination.

Case Seventeen. First Day. The dog urinated without difficulty but passed a very small amount of blood following urination. This was probably due to a slight opening in the wall of the urethra undetected at the time of surgery.

Second Day. The dog chewed some of the skin sutures out and the sutures had to be replaced.

Third to Sixteenth Days. The dog urinated in a normal manner and did not hemorrhage from the incision. The skin sutures were removed on the seventh day.

Case Eighteen. First Day. The dog urinated without difficulty but did not seem to have the normal force of urination. The lack of force was thought to have been caused by a slight swelling of the urethra and was of no practical significance.

Second Day. The dog urinated with normal force and appeared normal. Two skin sutures had to be replaced as they were partially torn out.

Third to Eighth Days. The dog urinated in a normal manner. The skin sutures were removed at five days.

Case Nineteen. First Day. The dog did not urinate. The

prepuce was manually retracted and the incision on the glans penis was examined and appeared to be entirely normal. No further examination or treatment was made.

Second Day. The dog urinated without difficulty. A slight scrotal irritation developed and was treated with a topical anesthetic creme. The prepuce was again retracted and the glans penis appeared normal at this stage of healing.

Third to Eighth Days. The patient urinated normally. The skin sutures were removed on the fifth day. The scrotal irritation subsided.

Case Twenty. First Day. The dog urinated without difficulty. The surgical area was healing normally and there was no hemorrhage from the preputial cavity.

Second to Seventh Days. The dog appeared entirly normal and urinated naturally. The skin sutures were not removed from this patient. Retraction of the prepuce and examination of the glans penis revealed a normal appearing glans penis.

Necropsy Observations

In all cases but case number seven, the skin incision healed by first intention. The parietal layer of the internal prepuce healed with the skin incision at the caudal aspect of the preputial cavity. This condition was not harmful to the animal and did not present any problems. There was no discharge from the opening.

In all cases the incision through the glans penis healed by first intention. These animals were necropsied at various

postoperative times so the catgut suture material was present in the early cases and completely absorbed in the later postoperative cases.

The healing of the closure of the penile fascia over the body of the penis was normal in every case and in only a very few cases was there any excessive fibrous tissue formation. The amount of fibrous tissue formed did not apparently interfere with urination.

Examination of the erectile spaces did not reveal any abnormal conditions. The corpus cavernosum urethrae was intact and entirely normal as observed by gross dissection. The bulbus glandis was normal in all cases but one. In this case there was excessive fibrous tissue formation where the bulbus glandis attached to the roughened area on the lateral wall of the urethral groove. The bulbus glandis apparently adhered to the remaining "saddle" of the os penis following surgery. The erectile spaces appeared normal.

The branches of the dorsal artery of the penis in most cases were normal. The superficial branch of the dorsal artery as it lay on the ventral aspect of the glans penis was cut in most surgical procedures when incising the glans penis to expose the os penis. There was enough collateral circulation so that this did not present a problem. The deep branch of the dorsal artery as it lay on the lateral wall of the urethral groove was incised in some cases. In those cases where it was not incised, not enough of the urethral wall was removed.

Examination of the remaining portion of the os penis pre-

sented a number of various observations and recommendations for further development of the surgical technique. In most cases most of the lateral wall of the os penis was removed on one side. No particular side was removed so there would be a comparison between sides removed. As far as could be determined by gross dissection there was not excessive callous formation on the cut edge of the os penis that would interfere with urination or obstruction of the urethra. It was observed that in those cases where there was an insufficient removal of the lateral wall, there were two areas that were more prominent than others remaining. The main and most difficult area of the lateral wall to remove was the caudal portion on the base of the os penis where the corpus cavernosum penis and tunica albuginea attached. The second area of the lateral wall that was no sufficiently removed was at the middle of the lateral wall at the level of the roughened area for attachment of the bulbus glandis to the lateral wall of the groove of the os penis. Both of these situations could be eliminated by making a bolder cut through the lateral wall with the bone cutting instrument.

DISCUSSION

The prepuce, as found in this study, did not differ materially as found in other writings. Bradley (1959) described the prepuce as having a double parietal layer and a visceral layer covering the glans penis. Miller (1952) and Sisson and Grossman (1953) described the prepuce as having three layers of integument, the outer layer which was ordinary skin and two

inner layers. Nickel, Schummer, and Seiferle (1960) described the prepuce as composed of ordinary skin and parietal and penile layers. Ellenberger and Baum (1943) considered the prepuce to be comprised of integument and visceral and parietal layers. This author consedered the prepuce as composed of an external layer of ordinary integument and an internal layer comprised of parietal and visceral (penile) layers.

The general topographical subdivisions of the penis was consistant with all authors. The penis consisted of the root, body, and glans penis. Miller (1952) stated that the body extended from the root to the glans and the glans was composed of two erectile bodies surrounding the os penis. He included the os penis was a part of the glans. Christensen (1954) indicated that the proximal or caudal portion of the os penis was included as a part of the body of the penis. Ellenberger and Baum (1943) stated that the os penis was a foundation for the glans penis. Nickel, Schummer, and Seiferle (1960) divided the corpus cavernosum penis into two parts, the cavernosus caudal part and the bony cranial part. Sisson and Grossman (1953) stated the os penis was the cranial part of the penis and did not classify it as to whether it was a part of the body or the glans penis. It was the opinion of this author that the termination of the body of the penis was at the attachment of the corpus cavernosum penis to the os penis. The os penis should be considered a structure of the glans penis even though it was a developmental structure of the corpus cavernosum penis.

The penile fascia was considered by Christensen (1954) as

only that part separating the pars longa glandis from the bulbus glandis. This author recognized this particular layer but also considered this layer to be continuous with the penile fascia surrounding the body of the penis, retractor penis muscle, collateral vessels of circulation, enclosing the dorsal vessels of the penis, and attaching to the fascia of the abdominal wall.

The angioarchitecture of the penis was excellently described by Christensen (1954). Many of the other authors only mentioned the major arterial trunks with little or no description. Chauveau (1901) indicated that the median septum between the two erectile spaces of the corpus cavernosum penis was incomplete. This statement was found to be erroneous in this work. Miller (1952) made the statement that the erectile tissue of the glans penis was separate from the corpus cavernosum urethrae. This statement was found to be incorrect in that the corpus cavernosum urethrae communicated with the bulbus glandis by several erectile shunts or anastomotic vessels on the ventral surface of the bulbus glandis.

The anatomy of the os penis and its cartilage was inadequately described in the material reviewed. Most authors reviewed revealed only that amount of information to orient the presence and a few relationships of the os penis. Ruth (1934) made a study of the development of the os penis in the white rat. All authors agreed that the os penis was developed from the corpus cavernosum penis. There was no direct statement as to the origin of the cartilage of the os penis.

Development of Surgical Technique

A thorough review of the literature did not reveal any material that pertained directly to the surgical technique developed by this author. Numerous authors had described the standard external urethrotomy procedure and some of the sequela following the urethrotomy. Barchfeld (1956) described the external urethrotomy and indicated that in most cases the obstruction was located just caudal to the os penis. He suggested that the wound be sutured to prevent delayed healing by controlling recurrent hemorrhage from an open incision. He controlled hemorrhage during the procedure by clamping the body of the penis below the ischial arch with tongue forceps. A plastic catheter was inserted and sutured into the urethra from the urethral orifice and left in place five days. A catheter was not inserted in any dogs with this author's cases.

Bower$_{8}$ (1944) performed a urethrotomy in a dog and the dog bled to death thirty-six hours postoperatively. In several cases of this authors work there was hemorrhage from the preputial cavity but was of no significance. This usually only occurred when the lumen of the urethra was accidently incised during the surgical procedure.

The article written by Brodey (1955) suggested that cystic calculi be checked before performing a urethrotomy as the condition would soon recur if one of the cystic stones dislodged and blocked the urethra. He stated that it was advantageous to establish a permanent urethral fistula just caudal to the os

penis. Krabbe (1949) and Markowitz, Archibald, and Downie (1959) suggested the placing of a urethral catheter and establishing a permanent urethral fistula. It was the intent of this paper to avoid such an occurrence by removal of the lateral wall of the urethral groove of the os penis to allow otherwise obstructive calculi to pass. Brodey (1954) in another article described the urethrotomy in a four-month old puppy where the calculus was removed and the incision allowed to heal without creating a permanent fistula.

McCunn (1947) stated that in the majority of cases the calculus lodged caudal to the os penis. He advocated the external urethrotomy procedure but warned that the chief post-surgical dangers were those of stricture or the presence of another stone which may escape from the urinary bladder. Cozzens (1932) described similar conditions that may affect the future urinating habits of the dog. He stated that removal of obstructive calculi just caudal to the os penis often resulted in damage to the urethra, and after this operation had been performed several times urethremphraxis or urethrostenosis nearly always followed as healing took place. If this condition took place he created a permanent urethral fistula just below the ischial arch.

Fish (1906) deviated from the normal ventral approach for the urethrotomy. Instead, he made a lateral incision through the side of the prepuce and into the urethra. This was performed in two instances on the same dog, one on the right side and one on the left side. Apparently this was done to delay scar for-

mation on subsequent operations. However, in each instance, an orchitis developed with considerable swelling and pain.

Fuller (1939) described a dog that was presented with typical symptoms of urethral obstruction. In this instance, the urethral calculus was lodged within the urethral groove of the os penis. An external urethrotomy was performed. Eight months later the same dog was again presented with a recurrence of the condition.

Harding and Sumner (1955) related a series of events that caused them to abandon the surgical approach after two urethrotomies and resort to medical treatment. On two separate occassions this particular dog was presented for acute urine retention by urethral obstruction by calculi and each time a urethrotomy was performed. On the third occassion surgery was deemed inadvisable. Sterling (1954) also described a similar situation. These particular types of cases would be the type that would benefit from the type of surgical technique developed by this author.

In contrast to current methods of surgical intervention Hill (1884) advocated that surgery was not indicated in cases of urethral obstruction. The only treatment was that of passing the catheter.

Mayer, Lacroix, and Hoskins (1957), Milks and Muldoon (1917), O'Connor (1912), Muller and Glass (1923), O'Connor (1952), Springer (1910), Steel (1888), White (1902), and Woodruff (1912) described the external urethrotomy. Some of the authors advocated suturing the skin incision and some said to let it heal as an

open wound. They were pretty much in agreement that urethral stricture was not an uncommon occurrence following this type of surgery, especially if more than one urethrotomy had been performed in recurrent obstructive cases.

The techniques used in this study had never been reported on in the literature so this material could not be directly discussed as compared to existing knowledge. However, several comparisons could be made concerning the advantages of this technique as compared with the existing external urethrotomy method and permanent urethral fistula method.

The external urethrotomy technique was the usual method employed on initial cases of obstructive calculi. In the event of recurring cases additional urethrotomies had to be performed to alleviate the condition. When this was done scar formation occurred at the incision site with a resulting stricture of the urethra. This added to the already existing problem. A permanent urethral fistula had to be established to permit a free passage of urine. This of course impaired the ability of the dog to copulate, enhanced the possibilities of the development of urinary tract infections, and caused a local inflammation of the area where the urine was voided onto the skin. The use of this new surgical technique could alleviate the above mentioned sequela.

This new surgical technique shall be called the "Penile Partial Ostectomy Technique".

SUMMARY

The gross anatomy of the dog penis and prepuce was studied so that the surgical technique could be undertaken. The process of erection in the dog was reviewed so certain vessels and erectile mechanism structures could be avoided as much as possible during the surgical procedure. The necropsy observations were briefly summarized.

The prepuce was divided into two portions. The external prepuce was that part composed of ordinary skin with hair. The internal prepuce was composed of parietal and visceral layers. The visceral layer covered a part of the glans penis and the parietal layer interposed between the visceral layer and the external prepuce. Its blood supply was derived from the external pudendal artery and the preputial branch of the dorsal artery of the penis.

The penis was divided into three main segments: the root, body, and glans penis. The literature was not clear as to the division between the body and glans penis. This author made the dividing line at the junction or attachment of the corpus cavernosum penis and tunica albuginea to the caudal truncated portion of the os penis. Everything cranial to that junction was termed glans penis and everything caudal was body of the penis.

The corpus cavernosum penis, corpus cavernosum urethrae, bulbus glandis, and pars longa glandis were recognized as erectile spaces of the penis. The corpus cavernosum penis and a part of the corpus cavernosum urethrae constituted a part of

the body of the penis, and the pars longa glandis, bulbus glandis and the cranial portion of the corpus cavernosum urethrae constituted a part of the glans penis. The corpus cavernosum urethrae was directly connected with the bulbus glandis by numerous erectile shunts which conveyed erectile blood to the bulbus glandis. The pars longa glandis was directly connected to the bulbus glandis by the deep vein of the glans which also carried blood to the bulbus glandis during the process of erection. The cavernosus spaces of the corpus cavernosum penis did not connect with any of the aforementioned erectile bodies.

The penis had as its main blood supply the dorsal artery of the penis. The dorsal artery had three main terminal branches caudal to the bulbus glandis. The superficial branch supplied the ventral surface of the glans penis, the deep branch supplied the pars longa glandis and the preputial branch supplied the parietal layer of prepuce and anastomosed with the preputial branch of the external pudendal artery which also supplied the penis. The dorsal artery and its branches also had anastomotic branches to the deep artery of the penis and the artery of the urethral bulb.

The os penis and its cartilage was divided into four portions and the relations of each part was described. The urethral groove was described.

The only musculature of the penis that was considered was the retractor penis muscle. The cranial attachment and relations of the muscle to the ventral surface of the body of the penis was described.

The surgical technique was altered in several ways to develop a consistant uniform method. The skin and fascia was incised on the ventral midline from just caudal to the preputial orifice to the cranial base of the scrotum. The parietal layer of internal prepuce was incised to the fornix preputialis and the glans penis brought out through the incision. The dorsal vessels of the penis were temporarily ligated to control hemorrhage of the surgical site. The corpus cavernosum urethrae was dissected away from the tunica albuginea on the body of the penis and from the lateral wall of the urethral groove. The dissection was done only on the side to be removed. The pars longa glandis and the erectile shunts connecting the corpus cavernosum urethrae and bulbus glandis were incised at the same time the corpus cavernosum urethrae was separated from the os penis. The bulbus glandis was then dissected from the "saddle" of the os penis on the side to be removed. At this point the deep branch of the dorsal artery was sometimes unavoidably cut as it lay between the "saddle" of the os penis and the deep surface of the bulbus glandis. The lateral wall of the urethral groove was then removed. Care was exercised to make a bold cut so as to remove as much lateral wall of the os penis as possible. It was important to leave the cut surface of the bone as smooth as possible.

Closure of the incised glans penis was performed using 00 to 0000 medium chromic catgut with a simple continous suture. Care was taken to get direct apposition of the incised edges. The fascia over the body of the penis was closed in a similar

manner. Care was taken to avoid placing sutures into the branches of the dorsal vessels of the penis and into the belly of the retractor penis muscle. The parietal layer of the internal prepuce was closed also in a similar manner. The skin was closed using a non-absorbable suture in a simple interrupted suture.

The dogs were observed postoperatively from one to one hundred and forty-five days. During the postoperative period in most cased recovery and healing was uneventful. Hemorrhage of short duration from the urethral orifice was the most frequent postsurgical sign when the lumen of the urethra was accidently incised. Following the postoperative period the dogs were euthanized and examined. In most cases the healing was by first intention and without complications. The only unfavorable factor observed in a few cases was the presence of a portion of the lateral wall of the urethral groove. This could have been eliminated very easily if the bone removal had been more extensive.

Photographs were taken of the above described surgical technique.

It was hoped that this study would provide a suitable amount of anatomical knowledge and correlation of knowledge of the related area and a development of a new surgical technique for the prevention of obstructive urethral calculi caudal to and within the os penis of the dog.

This new surgical procedure shall be called the "Penile Partial Ostectomy Technique".

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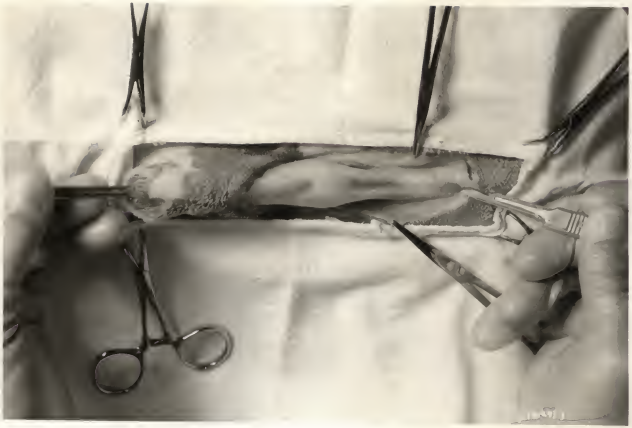
APPENDIX

EXPLANATION OF PLATE I

The initial skin incision is shown through the external layer of prepuce and over the body of the penis. Note the grooved director in place and the caudal extent of the incision to the base of the scrotum. Anatomical features to be noted are the retractor penis muscle, superficial branches of the dorsal artery of the penis, penile fascia, parietal layer of internal prepuce, shunts into the bulbus glandis, and body of the penis.

PLATE I



EXPLANATION OF PLATE II

Illustrated is the isolation and ligation of the dorsal vessels of the penis using a small diameter piece of rubber catheter. It was necessary to incise the penile fascia dorsal to the body of the penis to insert the tubing around the vessels. Note the terminal branches of the dorsal artery of the penis.

PLATE II

EXPLANATION OF PLATE III

Illustrated is the initial point of incision when the corpus cavernosum urethrae was separated from the tunica albuginea on the side to be removed. Note the glans penis had been removed from the preputial cavity, the retractor penis muscle relaxed and reflected laterally towards the surgeon and exposure of the corpus cavernosum urethrae.

PLATE III

EXPLANATION OF PLATE IV

Illustrated is the length of incision through the erectile tissue of the penis. The cranial extent of the incision extended a little beyond the urethral groove of the os penis. Care was exercised to avoid cutting the wall of the urethra.

PLATE IV

EXPLANATION OF PLATE V

Illustrated is the reflection of the pars longa glandis and bulbus glandis from the lateral aspect of the os penis on the side to be removed. This reflection extended to slightly beyond the caudal level of the os penis and cranial to the cranial extent of the urethral groove. Note the deep branch of the dorsal artery of the penis at the point of the knife blade. The urethral catheter was in place.

PLATE V

EXPLANATION OF PLATE VI

Illustrated is the beginning of the removal of the lateral wall of the os penis after the erectile tissue had been sufficiently dissected away from the os penis. Notice the position of the urethra within the urethral groove. The urethral catheter was in place. The surgeon in this procedure had changed sides of the operating table to allow for the cranial to caudal cutting procedure. The base of the os penis was grasped between the thumb and forefinger to provide maximum support.

PLATE VI

EXPLANATION OF PLATE VII

Illustrated is the removed lateral wall of the urethral groove of the os penis on the side to be removed. The wall had to be removed in several small pieces. The cut surface of the corpus cavernosum penis is visable and did not hemorrhage severely when incised. Note the angle of the cut. The urethra is seen in place. It was necessary to make the cut edge of the remaining bone as smooth as possible.

PLATE VII

EXPLANATION OF PLATE VIII

Illustrated is the closure of the incision through the glans penis to the fornix preputialis and beginning closure of the fascia over the body of the penis. Note that the rubber catheter used to ligate the dorsal vessels of the penis had been removed. Care was taken to avoid placing sutures through the dorsal vessels of the penis and through the belly of the retractor penis muscle.

PLATE VIII

EXPLANATION OF PLATE IX

Illustrated are the many different sizes and shapes of the os penis. Specimen G was taken from a dog with a fractured os penis. Specimens A and B illustrate a comparison between the normal os penis presurgically A and an os penis B in which the lateral wall of the urethral groove of the os penis had been removed surgically.

PLATE IX

ANATOMICAL AND SURGICAL CONSIDERATIONS OF THE OS PENIS OF THE DOG AS RELATED TO CORRECTION OF URETHRAL OBSTRUCTION BY CALCULI

by

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The anatomy of the penis, prepuce, and os penis was studied in the dog. The development of a surgical technique for the alleviation of recurrent obstructive urethral calculi was undertaken. The frequency of obstructive recurrent urethral calculi necessitated an improvement of the external urethrotomy method.

Twenty-five male dogs were used for the anatomical studies. They were embalmed and injected with latex in the arterial system. A study of the anatomy of the surgical area revealed several features not completely described in the literature reviewed. A gross dissection study was made of the os penis and the relationship of the erectile tissues surrounding the os penis. These areas were studied so that the mechanism of the process of erection would be interfered with to a minimum during surgery.

Twenty male dogs were used for the development of the surgical technique. The surgical technique was varied in several instances to develop a standard method. The dog was prepared for aseptic surgery in the routine manner and placed in dorsal recumbency. A skin incision was made on the ventral midline of the prepuce and over the body of the penis. The incision extended from just caudal to the preputial orifice to the base of the scrotum. The parietal layer of the internal prepuce was incised to the fornix preputialis and the glans penis extruded through this incision. The dorsal vessels of the penis were temporarily ligated to control hemorrhage. A woven catheter was placed within the lumen of the urethra. A pair of pointed scissors were then used to dissect the corpus cavernosum

urethrae from the tunica albuginea on the body of the penis and from the lateral wall of the urethral groove on the side to be removed. The pars longa glandis and the bulbus glandis were also incised during the preceding procedure. The bulbus glandis was dissected from the "saddle" of the os penis on the side to be removed. The lateral wall of the urethral groove was removed using bone cutting forceps. Hemorrhage was controled before closure of the incisions. The incision through the glans penis was closed using 00 to 0000 medium chromic catgut in a simple continous suture. Care was taken to have direct apposition of the incised edges. The penile fascia over the body of the penis was closed in a similar manner as the glans penis. The skin incision was closed using a simple interrupted non-absorbable suture.

Photographs were taken of the surgical technique.

Postoperative observations were conducted from one to one-hundred and forty-five days. Healing by first intention occurred in most dogs. A urethral catheter was not used post-surgically. All dogs urinated on the first and succeeding post-operative days. Three dogs hemorrhaged from the urethral orifice following urination for several postoperative days. This was attributed to the incised lumen of the urethra during surgery. This hemorrhage was not considered significant and usually stopped on the third postoperative day.

It was hoped this study would provide a suitable amount of anatomical knowledge of the related area for use in the develop-

ment of a surgical technique for the prevention of obstructive urethral calculi caudal to and within the os penis of the dog.

This new surgical procedure shall be called the "Penile Partial Ostectomy Technique".