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Evaluation of Autoligation Technique for Castration in Small Breed Dogs

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Abstract : The objective of the present study was to evaluate the effectiveness of autoligation techniques for castrating healthy male small breed dogs. Forty dogs were divided into four groups, with 10 in each group, based on maturity and the surgical technique used: 1) immature dogs aged less than 1 year, with autoligation of the spermatic cord via a scrotal approach (SAL) as the surgical technique (SAL-IM); 2) mature dogs aged 1 year or older, with the same SAL surgical technique (SAL-M); 3) immature dogs aged less than 1 year, with double ligation of the spermatic cord with an absorbable suture via a prescrotal approach (PDL) as the surgical technique (PDL-IM); and 4) mature dogs aged 1 year or older, with the same PDL surgical technique (PDL-M). The effectiveness of the surgical technique was evaluated by comparing the operating time and complications between these four groups. The significant decreases in operating times were found in SAL-IM and SAL-M compared with those of PDL-IM and PDL-M ($p < 0.01$ and $p < 0.01$). Regardless of maturity, the SAL surgical technique reduced operating time by approximately 69.5% compared with the PDL surgical technique. When the complication severities were scored, the results showed no significant differences among the four group. The autoligation technique for castration in healthy male small breed dogs is considered to be effective because the operating time consuming is less than conventional techniques.

Key words **:** small breed dogs, castration, scrotal approach, autoligation technique.

Introduction

Castration is one of the most common surgical procedures performed on dogs in clinical veterinary medicine. This elective surgery is performed for the following purposes: prevention of hormone-related diseases, behavior modification, and population control. While castration surgery is performed for therapeutic purposes, it is more frequently used for prophylactic purposes at an early age.

Castration has been performed by many surgeons for a long time, allowing for various studies to be conducted that evaluate the effectiveness of techniques for this procedure. Injection of chemical sterilant, such as zinc gluconate (7) and calcium chloride (6), has not garnered much attention due to issues regarding tissue necrosis caused by excessive chemical reactions. Other techniques, including laparoscopic vasectomy (8) and use of polyglycolic-based resorbable self-locking devices (4), have been introduced, but they were unable to replace conventional surgical techniques from a practical standpoint.

Ongoing studies are investigating faster and safer surgical techniques and postoperative care in clinical veterinary medicine. In particular, the needs for high volume and high-quality neutering programs, especially for shelter animals, have continued to drive research for more effective alternatives. In 2015, one study found that using a scrotal midline approach instead of the traditional prescrotal approach could reduce adverse effects and shorten operating time by approximately 30% in dogs (15). In 2016, autoligation of the spermatic cord, as in feline castration, was presented as an effective early-age castration method (2). A recent study found that autoligating the spermatic cord without suture material was faster and safer than the conventional technique in pediatric and juvenile dogs (10).

An autoligation technique using hemostatic forceps instead of a suture has been used in cats for a long time. In addition to castration, ovariohysterectomies have been performed using a pedicle tie with autoligation of the ovarian vessels by creating a window to the broad ligament, which allows the operation to be completed safely and more quickly (9).

The traditional double ligation technique has been preferred for dogs because performing the ligation is more difficult due to the testicular vessels forming an extensive pampiniform plexus. However, autoligation may be feasible in young puppies, since their pampiniform plexus has not yet formed completely, and in mature small breed dogs, since their pampiniform plexus diameter is smaller compared with that in large breed dogs.

To the best of the author's knowledge, although there has been a study of castration using autoligation of the spermatic cord in pediatric and juvenile dogs (10), this is the first study to evaluate autoligation in mature and small breed dogs.

The objective of the present study was to evaluate the effectiveness of the autoligation technique for castrating small breed dogs based on operating time and complications.

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Materials and Methods

Animals

Medical records of 40 intact, healthy, male, small breed dogs, weighing less than 7 kg, that were admitted to the VIP Animal Medical Center (Seongbuk) from September 2018 to August 2019 were retrospectively reviewed. Castration was performed on 80 normal testicles from a total of 40 dogs. The dogs were divided into four groups based on maturity and the surgical approach used: immature and mature dogs with double ligation via a prescrotal approach (n = 10 each, PDL-IM and PDL-M, respectively) and immature and mature dogs with autoligation via a scrotal approach (n = 10 each, SAL-IM and SAL-M, respectively). Medical records included patient information, preoperative blood test results, radiography findings, operation time, and postoperative complications. Informed consent for surgery was obtained from each patient's guardian.

Laboratory tests

Complete blood counts and serum chemistry profiles were conducted preoperatively. Complete blood count was measured using the IDEXX Procyte Dx Analyzer (IDEXX Laboratories, Inc., Westbrook, ME), and serum chemistry examinations, including blood glucose, blood urea nitrogen, plasma creatinine, alkaline phosphatase, alanine aminotransferase, serum albumin, and serum globulin, were measured using the IDEXX VetLab Station (IDEXX Laboratories, Inc., Westbrook, ME).

Anesthesia

Before the operation, cefazolin (30 mg/kg) and tramadol (4 mg/kg) were administered intravenously. DZ combination, which is a mixture of Domitor (medetomidine 5 mg/5 mL) and Zoletil 50 (zolazepam 125 mg and tiletamine 125 mg/5 mL), was used as an injectable anesthetic agent. DZ combination was prepared by mixing Zoletil 50 powder with 5 mL of Domitor, and 0.03 mL/kg of the mixture was slowly administered by intravenous (IV) injection. In case of intraoperative arousal, an additional 0.01 mL/kg of DZ combination was administered. Upon completion of the operation, 0.1 mg/kg of ANTISEDAN (atipamezole 5 mg/ml), which is a reversal agent for medetomidine, was administered. The atipamezole dose was one-third of the DZ combination dose (mL) administered. During anesthesia, electrocardiography and body temperature measurement, as well as non-invasive blood pressure monitoring, were performed using the PVM-2703 bedside monitor (NIHON KOHDEN, Tokyo, Japan).

Surgical techniques

All surgical procedures were performed by a single surgeon.

Patients were placed in a dorsal recumbent position. The surgical site (scrotal and prescrotal regions) was clipped, disinfected, and prepared. The patients were divided into two groups based on the approach and the surgical technique: prescrotal approach with double ligation of the spermatic cord (PDL) and scrotal approach with autoligation of the spermatic cord (SAL). Open-type castration was performed in both groups by incision of the parietal vaginal tunic. A routine castration instrumental package was used in the PDL group, whereas the use of instruments was minimized in the SAL group (Fig 1).

In the PDL group, the testicles were held inside the scrotum and pulled upwards to the prescrotal area. A skin incision was made over the testicles, and they were exteriorized one at a time. The spermatic fascia and vaginal tunic over the testicle were incised, and the testicular parenchyma was exposed. Then, the vaginal tunic was pulled away from the testicle to dissect the ligament of the tail of the epididymis. The vaginal tunic was separated from the testicle and spermatic vascular cord and returned to the body cavity without additional suturing. The exposed spermatic vascular cord was transected after circumferential double ligations, as distally as possible, using 3-0 Maxon (Covidien, Mansfield, MA, USA), which is a monofilament absorbable suture polyglyconate. After checking for additional bleeding, 3-0 or 4-0 Blue Nylon (Ethicon Inc, Somerville, New Jersey, USA), a

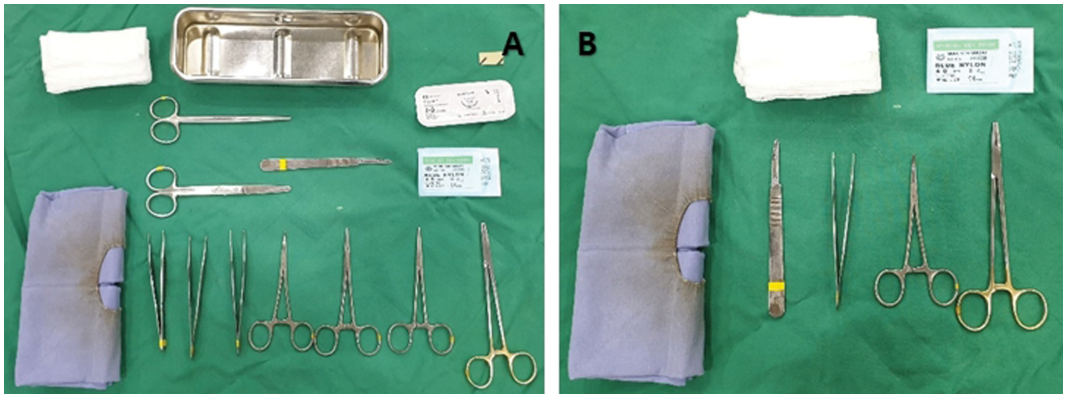

Fig 1. Comparison of surgical instruments between PDL and SAL groups. (A) Surgical instruments of PDL group; Needle holder, Halsted Mosquito hemostatic forceps (curved 1, straight 2), thumb forceps (Adson 1, Adson brown 1, rat-tooth 1), dissection scissors, Metzenbaum scissors, no. 15 blade, scalpel handle, gauze, surgical drape, absorbable suture material, and non-absorbable suture material. (B) Surgical instruments of SAL group; Needle holder, Halsted Mosquito hemostatic forceps, Adson brown thumb forceps, no. 15 blade, scalpel handle, gauze, surgical drape and non-absorbable suture material. The use of instruments is minimized in SAL group. PDL, Prescrotal approach with double ligation; SAL, Scrotal approach with autoligation.

non-absorbable suture material, was used to close the skin by forming one or two simple interrupted sutures, depending on the size of the incision.

In the SAL group, a scrotal midline incision was performed. The vaginal tunic was exposed and separated using the same method previously described for the PDL group. The testicle was held with the non-dominant hand, and Halsted Mosquito hemostatic forceps were placed above the spermatic cord. After using the hemostatic forceps to wrap the cord from top to bottom, the distal cord was brought to the tip of the hemostatic forceps. The deep area where the pampiniform plexus becomes thinner was held with the forceps to involve minimal tissue in the knot being formed. Subsequently, transection was performed away from where the knot was expected to form, and gauze was used to provide traction for the hemostatic forceps to form and tighten the knot. If there were no signs of additional bleeding, the knotted spermatic cord was released and returned to the body, as a result of the inherent tension. The skin was sutured using 3-0 or 4-0 Blue Nylon (Ethicon Inc, Somerville, New Jersey, USA) (Fig 2).

Operating time

In all surgeries, operating times were measured in seconds from the first skin incision to skin suture completion by the anesthesiologist.

Postoperative management

Cefazolin (30 mg/kg IV), famotidine (0.5 mg/kg IV), and tramadol (4 mg/kg IV) were administered before discharge. Strenuous exercise and bathing were restricted for postoperative stabilization. An appropriately sized plastic Elizabethan collar was placed on each dog. Each surgical site was disinfected twice a day using 0.05% chlorhexidine. Stitches were removed on the eighth day postoperatively.

Follow-ups for postoperative complications were performed before discharge, on the first day, and on the eighth day postoperatively. Two patients experienced moderate hematoma on the first postoperative day, and an additional follow-up was performed on the third postoperative day.

Postoperative complications

Postoperative complications included scrotal swelling, sub-

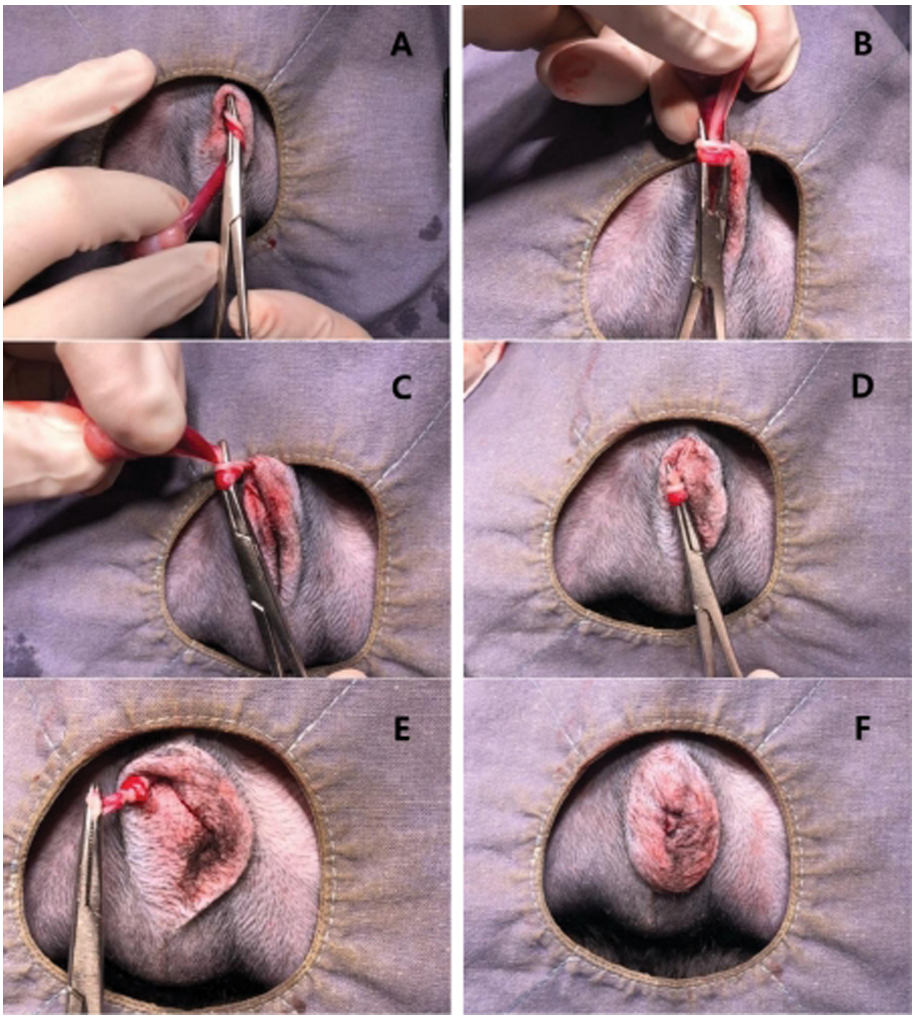

Fig 2. Autoligation technique procedures for castration. (A) Wrap the spermatic cord around the Halsted Mosquito hemostatic forceps. (B) Bring the distal spermatic cord to the tip of the hemostatic forceps. (C) Grasp the distal spermatic cord. (D) Transection of distal spermatic cord. (E) Traction of hemostatic forceps distally using gauze and slip tissue loop over cut edge. Tighten the autoligation knot and provide traction for the hemostatic forceps to form and tighten the knot. (F) Scrotal skin closure.

cutaneous bruising, hematoma, and self-mutilation. Although classifying complication severity was subjective, each complication was classified as mild, moderate, or severe and assigned 1, 2, or 3 points, respectively. A mild complication was defined as a slight change in appearance that did not require any involvement from the veterinarian or the guardian; a moderate complication was defined as a noticeable change in appearance that required additional follow-up by the veterinarian and the guardian; and a severe complication was defined as a serious change in appearance that required surgical intervention. The sum of all scores for each group was used to compare the severity of the complications.

Statistical analysis

Statistically analysis was performed using IBM SPSS Statistics version 24 (IBM, Armonk, NY, USA) for Windows. After the SAL and PDL groups were divided based on maturity, body weights and operating times in each of the four groups were normally distributed and compared using an independent t-test, while ages were not normally distributed and compared using a Mann-Whitney U test. The boxplot displays the distribution of operating time in each of the four groups (Fig 4). Postoperative complications violated normal distribution, and the Kruskal-Wallis test was performed. *P*-values < 0.05 were considered statistically significant.

Results

Signalments

The dog breeds included in this study were Maltese (n = 8), poodle (n = 8), Bichon Frise (n = 7), Pomeranian (n = 7), Chihuahua (n = 2), Mixed breed (n = 2), Boston terrier (n = 1), Italian greyhound (n = 1), Papillon (n = 1), Shetland sheepdog (n = 1), Shiba Inu (n = 1), Shit-tzu (n = 1), and Spitz (n = 1). These dogs maintain a body weight of ≤ 7 kg, even when fully mature.

The ages and body weights in each group were presented as mean ± standard deviation (SD). The mean ages were 5.7 ± 0.823, 20.9 ± 13.593, 6.3 ± 0.949, and 20.6 ± 9.901 months for SAL-IM, SAL-M, PDL-IM, and PDL-M, respectively. There were no significant differences in the ages between SAL-IM and PDL-IM ($p > 0.05$) and between SAL-M and PDL-M ($p > 0.05$). The mean body weights were 3.95 ± 1.358, 4.46 ± 1.516, 3.75 ± 1.474, and 4.85 ± 1.477 kg for SAL-IM, SAL-M, PDL-IM, and PDL-M, respectively. There were no significant differences in the body weights between SAL-IM and PDL-IM ($p > 0.05$) and between SAL-M and PDL-M ($p > 0.05$) (Table 1).

Table 1. Mean ages and body weights of dogs in each group

Group	Number of dogs	Age (months)	Body weight (kg)
SAL-IM	10	5.7 ± 0.823	3.95 ± 1.358
SAL-M	10	20.9 ± 13.593	4.46 ± 1.516
PDL-IM	10	6.3 ± 0.949	3.75 ± 1.474
PDL-M	10	20.6 ± 9.901	4.85 ± 1.477
Total	40	13.375 ± 11.021	4.253 ± 1.467

The ages and body weights in each group are presented as mean ± standard deviation (SD). There are no significant differences in the ages and body weights between SAL-IM and PDL-IM ($p > 0.05$) and between SAL-M and PDL-M ($p > 0.05$).
SAL-IM, Scrotal approach with autoligation in immature dogs; SAL-M, Scrotal approach with autoligation in mature dogs; PDL-IM, Prescrotal approach with double ligation in immature dogs; PDL-M, Prescrotal approach with double ligation in mature dogs.

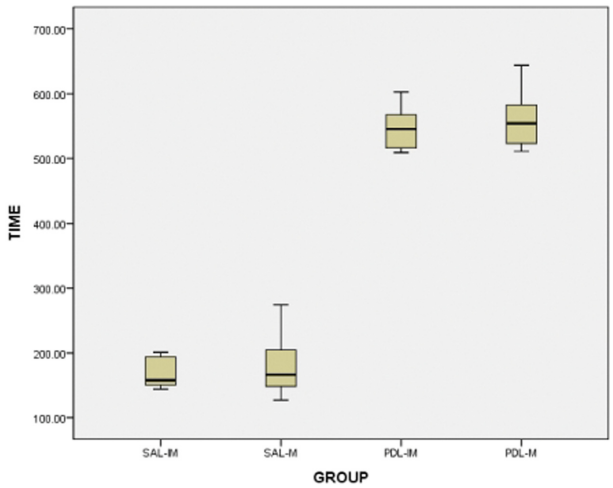

Fig 3. Boxplot of operating time (seconds) of each group. Despite of the maturity of each group, there are significant difference between the SAL and PDL groups ($p < 0.01$). The mean operating times of SAL and PDL are 174.5 seconds and 553.3 seconds. There is an approximately 69.5% reduction in operating time in the SAL group compared to that in the PDL group. There is no significant difference between SAL-IM and SAL-M groups ($p > 0.05$). SAL-IM, Scrotal approach with autoligation in immature dogs; SAL-M, Scrotal approach with autoligation in mature dogs; PDL-IM, Prescrotal approach with double ligation in immature dogs; PDL-M, Prescrotal approach with double ligation in mature dogs.

Anesthesia

The patients recovered from anesthesia without any complications following all surgeries. Two dogs each in the PDL-IM and PDL-M groups required the additional dose of anesthesia.

Operating time

There were significant differences in operating times between the SAL-IM and PDL-IM groups ($p < 0.01$) and between the SAL-M and PDL-M groups ($p < 0.01$). Regardless of the maturity of each group, there was a significant difference between the SAL and PDL groups ($p < 0.01$). The mean operating times of SAL and PDL were 174.5 seconds and 553.3 seconds, respectively. There was an approximately 69.5% reduction in operating time in the SAL group compared to that in the PDL group. There was no significant difference between the SAL-IM and SAL-M groups ($p > 0.05$) (Fig 3).

Postoperative complications

There were no cases with severe complications, and one case in each mature group experienced moderate complications including hematoma, swelling, and bruising. Dogs with moderate complications tended to have greater postoperative

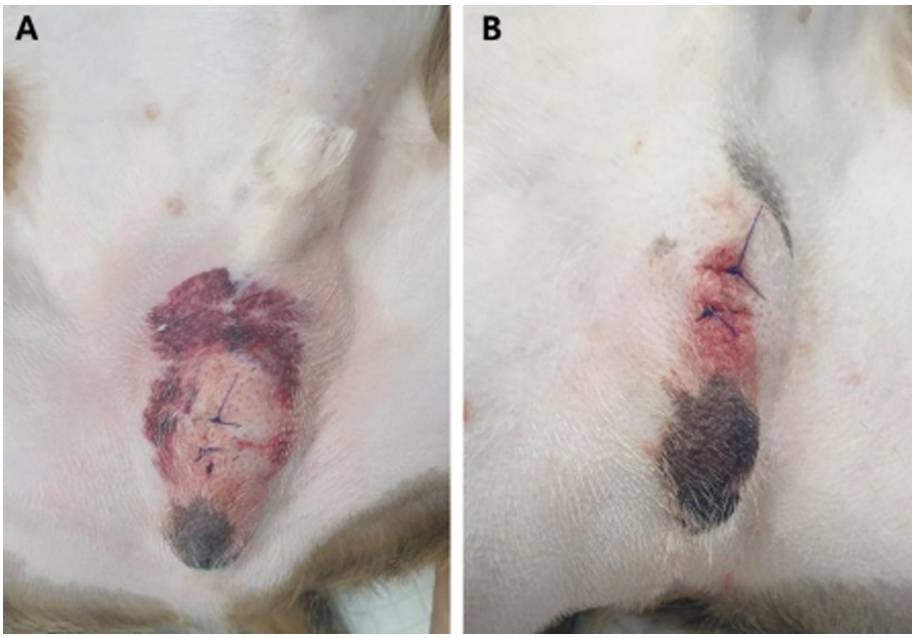

Fig 4. Postoperative complication of autoligation technique in a mature dog. A 13 months age Shit-tzu in SAL-M group has a moderate postoperative complication. (A) Moderate hematoma, scrotal swelling, and bruising on the first postoperative day. (B) Remained mild bruising on the eight postoperative day. SAL-M, Scrotal approach with autoligation in mature dogs.

Table 2. The number of dogs with postoperative complications and score of complications in each group

Group	Severity of complication	Number of dogs			Score
		Day 0	Day 1	Day 8	
SAL-IM	Mild	-	3	-	3
	Moderate	-	-	-	
	Severe	-	-	-	
SAL-M	Mild	1	2	1	6
	Moderate	-	1	-	
	Severe	-	-	-	
PDL-IM	Mild	-	4	1	5
	Moderate	-	-	-	
	Severe	-	-	-	
PDL-M	Mild	1	3	1	7
	Moderate	-	1	-	
	Severe	-	-	-	

There are no significant differences between the four groups when comparing complication severity ($p > 0.05$). However, the immature groups show lower scores than do the mature groups, while the SAL groups show lower scores than did the PDL groups.
SAL-IM, Scrotal approach with autoligation in immature dogs; SAL-M, Scrotal approach with autoligation in mature dogs; PDL-IM, Prescrotal approach with double ligation in immature dogs; PDL-M, Prescrotal approach with double ligation in mature dogs.

pain and self-mutilation (Fig 4). Application of ice on the surgical site reduced severity of complications.

The results showed no statistically significant differences between the four groups when comparing complication severity ($p > 0.05$). However, the immature groups showed lower scores than did the mature groups, while the SAL groups showed lower scores than did the PDL groups (Table 2).

Discussion

Various aspects of castration have been studied by many veterinarians, with recent efforts focusing on discovering more effective surgical techniques. This study is significant because of its reproducibility in that it compared outcomes from procedures performed by a single surgeon, rather than comparing existing outcomes from multiple surgeons (10).

With respect to operating time, a scrotal midline approach can reduce the operating time by approximately 30% compared to that of the conventional prescrotal approach has already been reported (15). The present study demonstrated that autoligation via a scrotal approach could shorten the operating time by approximately 69.5%. These findings support existing study results regarding application of the autoligation technique to juvenile and pediatric dogs in shelters (10). Further, these results suggest that this surgical technique can also be used on healthy small breed dogs weighing ≤ 7 kg. The SAL and PDL techniques showed a mean difference of 3 minutes and 19 seconds. Autoligation could be considered a significant time saving technique when SAL is applied in a high-volume and high-quality neutering program.

The anesthetic agent used in the present study was DZ combination, which is suitable for simple procedures such as castration (13). DZ combination can now be used safely and conveniently since a reversal agent for medetomidine became available and administration via the intramuscular route is possible. Thus, it could be selected as an effective anesthetic agent for a high volume and high-quality neutering program, especially for shelter animals. However, particular attention should be paid to dogs with pre-existing heart diseases (14).

In the present study, two cases each in the PDL-M and PDL-IM groups required additional anesthesia of one-third the standard dose as the operating time was increased. When

SAL was selected as the surgical technique, the procedure was completed within 4 minutes, offering the advantage of minimizing anesthesia time.

The appropriate use of analgesics can reduce the percentage of postoperative complications. In addition to tramadol, which was used in the present study, intratesticular lidocaine or bupivacaine could also be used as effective analgesics, since the drugs are inexpensive, and their administration is not technically difficult (11,12). In humans, the use of local anesthesia decreased the incidence of stress-induced complications and maintained a light plane of anesthesia, which resulted in a faster recovery from anesthesia (5). Even in cases that were not included in this study, previous experience showed that intratesticular local anesthesia offers improvements in postoperative pain and complications.

The two moderate complications in this study were not considered as a failure of ligature but considered as a failure of intact dissection of vaginal tunic, because the amount of postoperative bleeding was relatively small, empirically. Open type castration that involves a vaginal tunic incision has an approximately 1.5-fold higher complication rate than does closed type castration (3). Nevertheless, open type castration was performed in the present study for accurate and secure ligation by exposing the vessels directly and preventing the incorporation of vaginal tunic into the knot. Most complications that typically occur in open type castration cases involve bleeding in the vaginal tunic (1). When separating the vaginal tunic, it is important to accurately separate the ligament of the tail of the epididymis to prevent injury to the cremaster muscle and associated vessels attached to the tunic. In addition, the separated tunic can prevent bleeding in the vessels of the cremaster muscle by using the compressive force of the hemostatic forceps.

Methods for reducing complications caused by postoperative bleeding include accurate dissection and ligation. Based on the canine anatomy, the pampiniform plexus becomes thinner towards the distally from the testicle. Therefore, autoligation should be attempted deep to the pampiniform plexus to minimize the volume of tissue incorporated in the knot. If the pampiniform plexus and vas deferens have a large diameter, they can be autoligated separately.

The SAL technique is highly cost-effective because relatively expensive absorbable suture material is not used, and the use of anesthetic can typically be minimized. Moreover, the scrotal skin incision can be closed following the application of one or two drops of cyanoacrylate skin adhesive (10). In that case, use of the needle holder and skin suture material can be eliminated and the procedure can be performed with only blade, scalpel handle, Halsted Mosquito hemostatic forceps, and gauze.

The limitations of the present study include the small sample size, with application of the novel technique to only 10 mature and 10 immature animals. Like many studies of complications, the evaluation and comparison of their severity were subjective (1,3,10,15). Although a single veterinarian classified the severity based on pre-determined criteria, the views of other veterinarians could differ. The ultimate goal was to apply this surgical technique to shelter animals, but in the present study, the technique was applied only to dogs with a guardian. Application of this surgical technique to shelter animals is expected to lead to large differences in the difficulties in postoperative care.

Conclusion

Using autoligation via a scrotal approach in healthy small breed dogs is found to be effective because the operating time consuming is less than conventional techniques.

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