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Risk factors for reluxation after toggle rod stabilization for treatment of coxofemoral luxation in 128 dogs

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Abstract

Objective: Evaluate the risk factors for reluxation and outcomes for dogs with a toggle rod construct.

Study design: Retrospective case series.

Animals: One hundred twenty-eight client-owned dogs.

Methods: Medical records from 2007 to 2018 were reviewed for signalment, history, surgery, and outcome for dogs with a coxofemoral luxation repaired with a commercial toggle rod and nylon monofilament suture construct. Univariate and multiple logistics regression analysis were performed to assess risk factors associated with postoperative luxation. Primary veterinarians and owners were contacted for follow-up via telephone or electronic communication.

Results: The overall complication rate was 24.2%, and the reluxation rate was 14.8%. There was a decreased risk of reluxation when the cause was traumatic in origin (odds ratio [OR] 0.10) or when the lameness was severe at presentation (OR 0.42). Fifteen of 58 (25.9%) owners contacted completed a follow-up survey.

Conclusion: Dogs with nontraumatic, low impact luxations were at a higher risk for reluxation.

Clinical significance: Dogs of any body condition with a traumatic coxofemoral luxation are at lowest risk for reluxation.

1 | INTRODUCTION

The hip is the most common joint to luxate in companion animals, accounting for up to 90% of all luxations.[1-3] Most (79%–83%) coxofemoral luxations result from vehicular trauma; however, other causes include falls, hip dysplasia, and spontaneous luxations. [1-6] Craniodorsal is the most common direction of displacement of the coxofemoral joint and occurs in 73% to 96% of cases.[1,2,4]

Surgical and nonsurgical methods for treating hip luxation have been reported. Closed reduction is the preferred initial treatment of choice but has a reported reluxation rate of 43.5% to 47.3% and is contraindicated when there is evidence of coxofemoral pathology.[1,4,7] Features that can impact success of closed reduction include avulsion fractures of the ligament of the head of the femur, moderate to severe hip dysplasia, and polytrauma.[1,7] Surgical methods of coxofemoral luxation repair include capsulorrhaphy, extracapsular suture stabilization, trochanteric transposition, sacrotuberous ligament transposition, transarticular pinning, ischioilial pinning, deep gluteal muscle tenodesis, triple pelvic osteotomy, external skeletal fixation, and toggle rod stabilization [2,4,8-14] The toggle rod construct has been used successfully in a variety of species including dogs, cats, a miniature horse, and an alpaca.[6,8,15,16] Researchers have evaluated toggle rod constructs in multiple biomechanical studies using hand-made toggles of a Steinmann pin or Kirschner-wire, commercial toggle rods, and different sutures including nylon monofilament and braided multifilaments.[3,17,18] These in vitro studies provide evidence that, although various toggle rod constructs can sustain

41% to 47% of the load of the ligament of the head of the femur in intact specimens, they are likely sufficient for normal physiologic forces in the postoperative recovery period.[3,17,18]

The most frustrating complication after hip luxation repair is undoubtedly reluxation. Reported reluxation rates with toggle rod repair range from 0% to 25%.[2,4-6,8,19] Other complications with toggle rod fixation are infrequent but may include seroma, fever, infection, subluxation, sciatic nerve damage, wound dehiscence, postoperative swelling, and injury to the articular cartilage.[2,5,6,8] Researchers evaluating 62 cases of toggle rod repairs in a previous study found that dogs in which surgery time was less than 2 hours were significantly less likely to have a reluxation.[5] Body weight, comorbidities, time from injury to correction, and previous reduction have not been shown to affect outcome.[4-6,19]

Long-term follow-up of coxofemoral luxation repair has been assessed radiographically and via owner surveys. Radiographs have revealed varying levels of degenerative joint disease 1 year after successful reduction; however, changes observed on radiographs did not always correlate with clinical signs.[4] The survey instruments varied by study and investigated time to resolution of lameness, compliance with postoperative instructions, current limb function and activity levels, and overall satisfaction with the procedure.[2,5,6,20] Eighty-one percent to 88% of owners reported that their dog had good to excellent limb function postoperatively and were pleased with their dog's recovery.[2,5,6,20]

The objective of this study was to determine risk factors for reluxation in a large population of dogs whose coxofemoral luxations were treated by a single surgical method, toggle rod stabilization with a nylon monofilament suture and a commercially available toggle rod. Our hypothesis was that reluxation rates would be similar to those previously reported and that the presence of concurrent orthopedic injuries and preexisting coxofemoral pathology would be significant risk factors for reluxation. Our second hypothesis was that assessment of dogs' quality of life would be very good or excellent based on owner assessments.

2 | MATERIALS AND METHODS

2.1 | Animals

Medical records from January 2007 to December 2018 were reviewed to identify dogs that had toggle rod stabilization for treatment of hip luxation. Dogs were included when a nylon monofilament with a commercial toggle rod (Securos; Surgical AmerisourceBergen Corporation, Fiskdale, Massachusetts) was placed and the dog was discharged from the hospital. When a dog had bilateral toggle rod stabilization procedures, one hip was randomly chosen for analysis, and the second hip was considered a concurrent procedure. When the dog had multiple toggle rod stabilization procedures over time, one instance was randomly chosen for analysis and the others were excluded. Felines, cases in which a hand-made toggle rod (bent Steinmann pin) was used for repairs, and dogs that died before hospital discharge were excluded from data analysis.

Information obtained from the medical records included signalment, body weight, body condition score (BCS; 1 =too thin and 9 = obese), medical history, etiology of luxation, length of time from injury to hip toggle stabilization, characterization of the luxation, types of previous attempts at stabilization (open, closed, or none), and comorbidities. The latter was further divided into skin conditions, systemic conditions, and other musculoskeletal or neurologic comorbidities. Musculoskeletal and neurologic comorbidities were further categorized into underlying hip pathology; traumatic injuries; nontraumatic, noncoxofemoral joint pathology; and neurologic injuries. Luxation etiology was classified as traumatic (eg, high magnitude of force injury such as automobile trauma) or nontraumatic (eg, low magnitude of force injury such as running, playing). Surgery documents were evaluated for toggle rod and suture type, method used for securing the suture, and any additional procedures performed. Anesthesia records were evaluated for anesthesia and surgery duration. Immediate postoperative radiographs were evaluated for the presence of preexisting osteoarthritis in the luxated hip or contralateral hip, <50% coverage of the femoral head by dorsal acetabular rim in the contralateral hip, and features of chondrodystrophism by a board-certified surgeon (M.D.B.) blinded to all animal information.

2.2 | Procedure

Anesthesia and analgesic protocols varied according to the requirements of the individual dogs. One of five different board-certified surgeons performed each surgery or directly supervised a surgery resident. The surgical technique for toggle rod stabilization was performed as previously described.[20] Variations between the surgeries included the use of different strength monofilament nylon (20-, 40-, 60-, 80-, or 100-lb test) and differently sized commercially available toggle rods (2.7, 3.2, 4.0, and 4.5 mm). All sutures were tensioned by hand until the surgeon was confident that no slack remained. In addition, variations in how the nylon was secured to the

subtrochanteric area of the femur included the use of multiple square knots, a metallic crimp (Securos), or a polypropylene button.

2.3 | Outcomes

Follow-up information was obtained by calling the referring veterinarian for additional medical records and/or by contacting the owners directly via phone or email. Clients were not contacted when a dog was known to be deceased or when a dog was known to have undergone a second procedure for treatment of a complication. The follow-up survey evaluated the ability to follow activity restrictions (scale of 0 = did well to 5 = unable to comply), duration to resolution of lameness (weeks), current lameness (scale of 0 = no lameness to 5 = non–weight-bearing lameness), owner outcome rating (poor, okay, good, or excellent), any additional diagnoses or complications since surgery, and the Canine Brief Pain Inventory (CBPI; https://www.vet.upenn.edu/research/clinical-trials-vcic/our-services/pennchart/cbpi-tool). The CBPI was used to quantitate the presence and impact of pain as previously described in dogs with osteoarthritis.[21] The CBPI is divided into a pain severity score (PSS; 0 = no pain to 10 = extreme pain), pain interference score (PIS; 0 = does not interfere to 10 = completely interferes), and a quality of life score (poor, fair, good, very good, or excellent).

2.4 | Statistical analysis

Associations between each recorded variable and the presence of reluxation were assessed. Normal distribution was determined by the Shapiro Wilk test. Nominal and binary data were tested for association via a χ^2 test or the Fisher exact test when the data set was small. Discrete, ordinal, and continuous data were assessed by means of a Wilcoxon rank-sum test. Multivariate analysis was performed by using a multiple logistic regression analysis. Factors with a univariate $P < .20$ were entered in to the equation and removed according to the highest P values, retaining all factors with $P < .10$. Previously unused or deleted factors were then added to the model one at a time and retained when $P < .10$. Multicollinearity was assessed by means of variance inflation factor (VIF). All factors entered into the multivariate equation had VIF <2.0. Odds ratios and 95% confidence limits (CL) were estimated from the multiple logistic analysis. χ^2 Tests were used to evaluate the association of evidence of hip dysplasia and etiology of luxation. Data were analyzed in SAS version 9.3 (SAS Institute, Carry, North Carolina). Significance was set at $P < .05$.

3 | RESULTS

3.1 | Signalment and presentation

One hundred twenty-eight dogs met our study inclusion criteria. Breeds represented included mixed breed dogs (42), Labrador retrievers (9), terrier breeds (7), and a mixture of other purebred dogs (70). There were 13 (10.2%) intact females, 56 (43.8%) spayed females, 11 (8.6%) intact males, and 48 (37.5%) neutered males. Sex was not associated with the risk of reluxation ($P = .55$). The median body weight was 20.9 kg (range, 2.7-61). The BCS was recorded in 111 (86.7%) medical records, with a median score of 5 (range, 3-9). Seventeen (13.2%) dogs had a BCS ≥7. Body condition score and body weight were not associated with risk of reluxation (Table 1). The median age at presentation was 58 months (range, 4-176). The side of the luxation was left in 56 (43.8%) and right in 72 (56.2%)

TABLE 1 Univariate analysis of continuous data for dogs without or with reluxation

Variable	No postoperative luxation	Reluxation	*P* value
Body weight, kg	20.6 (9.5-27.8)	22.7 (10.2-29.6)	.48
Body condition score, 0-9	5 (5-6)	5 (5-6.8)	.90
Age, mo	57 (24-89)	66 (18-108)	.48
Lameness at presentation, 0-5	4 (3-5)	4 (3-4.5)	.11
Duration of injury, d	1 (1-3)	3 (1-7)	.04
Test size per body weight, lb	1.7 (1.5-2.5)	1.4 (1.2-2)	.18
Duration of anesthesia, h	2 (1.5-2.5)	2 (1.5-3)	.83
Duration of surgery, h	1 (1-1.5)	1 (1-2.5)	.60

Note: Values are median (interquartile range).

TABLE 2 Multiple logistic regression analysis to evaluate the outcome of relaxation

Variable	Odds ratio		*P* value
	Point estimate	95% Wald CL	
Traumatic etiology	0.10	0.02-0.70	.02
Lameness at presentation	0.42	0.19-0.96	.04
Concurrent traumatic musculoskeletal injury	6.14	0.87-43.46	.07
Test of monofilament per BW ratio	0.31	0.09-1.12	.07
Evidence of chondrodystrophy	8.28	0.7-97.63	.09

Note: N = 19.
Abbreviations: BW, body weight; CL, confidence limit.

TABLE 3 Types of musculoskeletal and neurologic comorbidities observed according to location and type of injury

Variable	Fractures[a]	Luxations[b]	Other musculoskeletal[c]	Neurologic[d]	Total locations of injury
Ipsilateral pelvic limb	13 (1)	7	8 (4)	1 (1)	29 (6)
Contralateral pelvic limb	16 (2)	10 (2)	5 (4)	2 (1)	38 (12)
Forelimb	1	3 (1)	0	3 (1)	7 (2)
Other	2	0	0	4	6
Total types of injury	32 (3)	20 (3)	13 (8)	10 (3)	

Note: N = 61. Thirteen dogs had ≥2 different comorbidities. Values are listed as total number of dogs (number of those with reluxation).
[a]Fractures identified included tibial, femoral, pelvic, rib, and radius/ulna fractures.
[b]Joint luxations included sacroiliac luxations, coxofemoral luxations, and elbow luxations.
[c]Other musculoskeletal comorbidity included medial patellar luxation, muscle atrophy, and degenerative joint disease of the stifle.
[d]Neurologic conditions included brachial plexus injury, intervertebral disc disease, spinal shock, and obturator neuropathy.

dogs. Three (2.3%) dogs had bilateral coxofemoral luxations. Coxofemoral luxations were craniodorsal in 125 (97.7%) and caudoventral in three (2.3%) dogs. Known high-impact traumatic events were the most common cause of hip luxation and occurred in 93 (72.7%) dogs; the most common was vehicular trauma in 75 (58.6%). For 12 (9.4%) dogs, there was a strong suspicion of unobserved vehicular trauma based on the presence of polytrauma. Other traumatic events occurred for 19 (14.8%) dogs, including being hit by a falling tree, hit by a falling gate, and an altercation with a cow. Known nontraumatic or low-impact events, including a small fall or jump, a misstep on a stair, slipping while running, altercation with another dog, or handling at a grooming facility, resulted in luxation in 20 (15.6%) dogs. The underlying etiology of luxation was unknown for 14 (10.9%) dogs. The dogs with unknown etiologies were not included when the risk of etiology on relaxation was evaluated. There was a decreased risk of reluxation (OR, 0.10; 95% CL, 0.02-0.70) when the cause was traumatic vs a low-impact origin ($P = .02$; Table 2). Dogs that presented with a higher degree of lameness had a decreased risk of reluxation (OR, 0.42; 95% CL, 0.19-0.96; $P = .04$; Table 2).

Toggle rod repair was performed ≤7 days after injury in 103 (84.4%) dogs and > 7 days after luxation in 19 (15.6%) dogs with known dates of injury. The median length of time between injury and initial surgery was 1 day (range, 1-120). Twenty-nine (22.7%) hips had an attempted closed reduction performed prior to toggle rod surgery, and two (1.6%) hips had a previous toggle rod placed. Duration of injury prior to repair was in the univariate analysis (Table 1) but did not increase the risk for reluxation in the multivariate analysis ($P = .23$). Neither duration of anesthesia ($P = .83$) nor duration of surgery ($P = .60$) influenced risk of reluxation in univariate (Table 1) or multivariate analysis.

Comorbidities included the presence of skin wounds in 50 (39.1%) dogs, systemic illness (cardiovascular signs such as arrhythmias, hypotension, pulmonary trauma; abdominal injuries) in 25 (19.5%) dogs, and/or other musculoskeletal or neurologic comorbidities (fractures, luxations, nerve deficits, osteoarthritis) in 61 (47.7%) dogs (Table 3). Determination of the presence of underlying coxofemoral pathology was based on radiographic evidence of hip dysplasia or osteoarthritis (Table 4). Five of 27 (18.5%) dogs with existing coxofemoral pathology had

TABLE 4 Frequency and significance of coxofemoral pathology for noncontinuous data via univariate analysis

Variable	Positive finding	No postoperative luxation	Reluxation	*P* value, univariate
Evidence of OA luxated hip	12	9	3	.36
Evidence of OA contralateral hip	9	6	3	.29
<50% coverage of femoral head by DAR in the contralateral hip	19	16	3	>.99
Normal coxofemoral joints radiographically	86	74	12	.77

Note: Radiographs for 113 dogs were available for evaluation. Data are number of dogs.
Abbreviations: DAR, dorsal acetabular rim; OA, osteoarthritis.

reluxation compared with 14 of 101(13.9%) dogs with no identified hip pathology and reluxation ($P = .55$).

3.2 | Radiographic evaluation

Immediately postoperative radiographs were available for evaluation in 113 dogs. Evidence of hip osteoarthritis was present in 12 (10.6%) dogs; hip osteoarthritis was bilateral in nine dogs and unilateral (luxated hip only) in three dogs. Ten (8.8%) dogs had evidence of dysplasia (<50% coverage of the femoral head by the dorsal acetabular rim) without osteoarthritis presence in the nonluxated hip. Four (3.5%) dogs could not be assessed for evidence of hip dysplasia because of fracture of the nonluxated acetabulum (3) or because of bilateral (1) luxations. Evidence of chondrodystrophism was present in 13 (11.5%) dogs. The appearance of chondrodystrophy based on subjective assessment of bone length, shape, and angular limb deformities did not contribute to reluxation ($P = .09$; Table 2). Eighty-five (75.2%) dogs had normal appearing coxofemoral joints according to radiographs. Normal hip joints did not decrease the risk of reluxation ($P > .99$; Table 4). Seven of 21 (33.3%) dogs with nontraumatic etiologies had evidence of underlying hip pathology compared with 17 of 93 (18.3%) dogs with traumatic etiologies ($P = .14$).

3.3 | Surgical procedure

A commercial toggle rod in conjunction with a monofilament nylon material was used in all surgeries. Surgery reports included details on the method used to secure the monofilament nylon to the subtrochanteric area of the femur in 94 procedures. A crimp was used in 14 (14.9%) procedures vs use of square knots in 80 (85.1%) procedures. A polypropylene button was used in 80 (85.1%) hips, with either a crimp or a knot. Use of a craniocaudal bone tunnel through the lateral cortex of the subtrochanteric area was employed in 14 (14.7%) procedures. Additional procedures were performed in conjunction with the passage of a toggle rod and suture in nine (7%) dogs; these included an additional toggle rod (3), iliofemoral band (3), and tension band stabilization for greater trochanter avulsion fractures (3). Neither the type of method used to secure monofilament nylon ($P = .51$) nor an additional procedure at the luxated coxofemoral joint ($P > .99$) was associated with risk of reluxation on the basis of univariate analysis. As the monofilament nylon test strength per body weight ratio increased the risk of reluxation decreased (multivariate analysis $P = .07$; Table 2). An additional procedure unrelated to the coxofemoral luxation was performed at a different site in 49 (38.3%) dogs to address comorbidities. The performance of concurrent surgery did not affect the rate of reluxation ($P = .38$).

3.4 | Postoperative care

No external coaptation was placed postoperatively in any dog for the coxofemoral luxation. All dogs were allowed to bear weight on the limb after surgery, and owners were instructed to enforce 6 weeks of activity restriction. Postoperative analgesic, antibiotic, anxiolytic, and other medications varied at the discretion of the surgeon.

3.5 | Postoperative complications

The most common postoperative complication reported was reluxation of the coxofemoral joint, which was observed in 19 (14.8%) dogs. The median number of days until reluxation occurred was 62 (range, 1-367). Among the 15 dogs with known outcomes after reluxation, 13 underwent surgical treatment and two were managed medically (Table 5**).** Potential mechanisms of failure documented included a toggle rod that pulled through the acetabulum (1), suture breaking (2), wearing of the

TABLE 5 Summary of the final outcomes of dogs with postoperative reluxation

Outcome of reluxation	n (%)
Femoral head and neck ostectomy	7 (37)
Total hip replacement	3 (16)
Toggle pin	3 (16)
Medical management	2 (11)
Unknown outcome	4 (21)

TABLE 6 Frequency of major and minor complications

Type of complication	Frequency, n (%)
Major complications, total	21 (16.4)
Reluxation	19 (14.8)
Intraoperative placement	1 (0.8)
Implant irritation	1 (0.8)
Minor complications, total	10 (7.8)
Subluxation	2 (1.6)
Osteoarthritis	7 (5.5)
Surgical site infection	3 (2.3)

dorsal acetabular rim (1), and no observable implant faults (3). One dog with a suspected implant-associated irritation required implant removal. Minor complications included medically managed surgical site infections, subluxations, and osteoarthritis (Table 6). Subluxation was observed in two dogs with clinical signs of lameness and/or pain on range of motion. Osteoarthritis was diagnosed in seven dogs on the basis of physical examination findings such as pain on manipulation, crepitus, or radiographic changes such as osteophytosis with appropriate coxofemoral joint reduction.

3.6 | Clinical outcome

The median follow-up time was 151 days (range, 0-4440). Follow-up information was collected solely from medial records when the dog was deceased (42) or had a second procedure for complications (13; Table 5). Fifteen dogs were lost to follow-up. Telephone and electronic communication was pursued for the remaining 58 dogs. Fifteen of the 58 (25.9%) clients that were contacted responded to the survey. Four of the 15 dogs had difficulty complying with activity restrictions. One of these four dogs had an untreated reluxation sustained after jumping a fence 1 day postoperatively. When the CBPI scores were evaluated, the median PSS was 0 (range, 0-3.25) and the median PIS was 0 (range, 0-3.5). A very good or excellent quality of life was reported in 13 of 15 dogs, and a good quality of life was reported in two of 15 dogs. Three dogs had additional concurrent neurologic or orthopedic conditions diagnosed at the time of survey completion.

4 | DISCUSSION

The results of this study provide evidence to support the findings reported in previously published articles that toggle rod stabilization is an efficacious technique for treating coxofemoral luxation. We report a rate of reluxation (14.8%) that is consistent with past reports of toggle rod stabilization (0%–25%).[2,5,6,8,19] We identified new risk factors for relaxation, including a low-impact or nontraumatic etiology and a lower degree of lameness at presentation. By contrast, other factors, such as duration of surgery, that have previously been shown to increase risk of reluxation were not found in this study. The BCS did not affect the rate of reluxation in this study. Previous studies have evaluated outcomes on the basis of body weight; however, to the best of the authors' knowledge, BCS has not been previously evaluated as a risk factor for reluxation.[5,19]

Hip luxation as a result of a high-impact traumatic etiology and a higher lameness score had lower odds ratios of reluxation compared with those of nontraumatic origin. Because of the expected high magnitude of force required to damage the primary and secondary stabilizers in a normal hip sufficient to cause luxation, it is logical to assume that luxation in the absence of major trauma should create concern for the presence of an underlying pathology. In addition, acute high-impact injury is more likely than low-impact injury to cause a more severe lameness. It is difficult to compare etiology of luxation as a risk factor among studies because there is inconsistency in what qualifies as traumatic vs or nontraumatic causes of luxation. In this study, falls, jumps, slips, and altercations with other dogs were considered nontraumatic or low-impact, but they have been previously grouped with traumatic incidences.[7] In this population of dogs, nontraumatic luxation was associated with risk of reluxation ($P = .02$).

Evidence of preexisting hip pathology including hip dysplasia and osteoarthritis had no effect on reluxation rates. Hip pathology has historically been stated as a contraindication for performing a toggle rod stabilization.[1,12] However, previous studies in which coxofemoral luxation has been examined have included cases with mild to moderate hip dysplasia.[2,5,6,8,9] Researchers in a previous retrospective study in which a toggle rod was used found that, of 10 hips with mild hip dysplasia, only one hip reluxated.[5] Other researchers have observed that dogs with hip dysplasia did not experience reluxation.[2,6] In the

current study, evidence of hip dysplasia was not associated with reluxation ($P = .55$). When we compared dogs with identified underlying coxofemoral pathology, 33.3% of dogs with a nontraumatic etiology had a reluxation, and 18.3% of dogs with a traumatic etiology experienced relaxation; there was no difference ($P = .14$), but this may have been the result of a type II error. A limitation of this study is the use of radiographic evaluation in the absence of preluxation history and previous physical examination findings to make the diagnosis of underlying coxofemoral pathology. The severity of the underlying hip pathology was not graded, and only presence or absence of signs was documented. This could have resulted in underestimation of the impact of severity of coxofemoral pathology on reluxation. Despite the evaluation of 128 dogs, a lack of association of reluxation with evidence of hip dysplasia may be the result of a type II error. Because only the etiology of luxation performed affected the risk of reluxation, and preexisting coxofemoral pathology did not affect the risk of relaxation, we reject our first hypothesis.

Polytrauma is commonly found in animals with coxofemoral luxation because of the high incidence of vehicular trauma as an etiology.[18] In the present study, dogs that underwent a concurrent procedure at a separate site were not at a higher risk of having reluxation ($P = .38$). This is in agreement with two other studies in which an association with concurrent procedures and the risk of relaxation was not found.[5,6] Demko et al[5] did find that dogs that underwent surgery with a duration ≥2 hours were more likely to experience reluxation. We did not find that length of anesthesia ($P = .83$) or surgery ($P = .60$) influenced the outcome in this population of dogs. There was no particular injury that was associated with the risk of reluxation, which is consistent with findings in other studies.[5,6,11,19]

The toggle rod constructs in this study were nylon monofilament suture and a commercial toggle rod. Different methods were used to secure the suture to the femur by the five surgeons; however, differing methods were not found to influence reluxation rate ($P = .51$). All procedures were performed at a single hospital, and multiple surgeons of varying levels of experience performed the surgeries. This could lead to variations in procedures such as hand tensioning of the nylon suture, which could potentially alter outcome. No quantitative measurements of suture tension were performed during any of the procedures included in this study. While the majority of medical records for dogs that experienced reluxation in this study did not contain the precise cause for failure, previous reports describe breakage of the suture as the most common reason.[3,4,6,8,18] The radiographs in our reluxation cases support this finding in that none revealed evidence of toggle rod displacement or breakage. Published recommendations on nylon monofilament suture test selection are based on bone tunnel size, which includes having a femoral tunnel ≤20% the width of the femoral neck or a tunnel of a maximum width of one-third the diameter of the bone.[2,8] Suture size to body weight ratio only approached significance ($P = .07$) in our study. Increasing test size of the monofilament nylon suture would be expected to provide increasingly better resistance to cycling, abrasion, and fatigue.[18]

Limitations of this study include its retrospective nature and low response rate to our survey (25.9%). Potential reasons for the low survey response rate include method of survey implementation, time from procedure to follow-up, and survey length. The low response rate provides a potential nonresponse bias resulting in an overestimation of the overall positive outcomes and an underestimation of complications. However, our complication rate was consistent with previously reported reluxation rates for dogs with toggle rod stabilization.[2,5,6,8,19] Thirteen of 15 survey respondents reported that their dog had a very good or excellent quality of life. This is in line with other reports that describe high owner satisfaction (81%–86%) and successful outcomes when hip luxation is repaired with a toggle rod construct.[2,5,6,20] Because our findings are in line with previous findings on toggle rod stabilization, we accept our second hypothesis that dogs with toggle rod stabilization would have a good quality of life despite the low response rate.

Future studies could evaluate larger populations with different constructs and specifically grade the degree of underlying coxofemoral and concurrent pathologies. Different modalities such as arthroscopy could be used in future studies to assess for preexisting joint pathology and joint health to evaluate for risk factors specific to the coxofemoral joint and help with patient selection. This study provides evidence that dogs of any body condition ($P = .90$) are candidates for a toggle rod stabilization of a coxofemoral luxation. Dogs with a traumatic coxofemoral luxation ($P = .02$) and with a higher severity of lameness ($P = .04$) are at the lowest risk for reluxation.

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AUTHOR CONTRIBUTIONS

Mathews ME, DVM: Completed medical record review, data accumulation, and writing of the article; Barnhart MD, DVM, MS, DACVS: Evaluated radiographs and provided guidance for objectives, hypotheses, and revisions.

CONFLICT OF INTEREST

The authors declare no conflicts of interest related to this report.

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