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Efficacy of Modified Toggle Splint with Nylon Suture for Stabilization of Coxofemoral Luxation in Dogs

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A B S T R A C T

Coxofemoral luxation is a common orthopedic lesion in dogs. This study aimed to evaluate the effectiveness of a modified toggle splint with nylon suture as a prosthetic teres ligament for reducing and fixing coxofemoral luxation in dogs. Five adult mongrel dogs weighing 15±2 kg were used in this experimental study. The toggle splint was fabricated from a Steinmann pin (1cm length, 2mm diameter) by drilling 0.5 mm hole in the center. Stabilization of coxofemoral joint was performed by a modified Toggle splint technique. A tunnel, from the major trochanter through the fovea capitis to the acetabulum, was performed in which the toggle splint was passed through, and nylon suture was used for fixation. Dogs were scored for lameness severity at 0-, 14-and 42-day post-operation using a numerical rating scale (NRS) with 5 levels, and reductions were assessed radiographically at three-time points the day of operation, day 28th, and day 42nd. The results showed that the treatment splint was effective in achieving good reduction and fixation in four out of five (80%) dogs at all time points. Reluxation was observed only in one dog (20%) up to week 6 post-operation. The mean lameness score on day 14 (2.0±0.87) and 42 (0.60±0.60) were significantly lower ($P<0.001$) compared to day 0. These results indicate that the modified toggle splint with nylon suture is a promising treatment option for canine coxofemoral luxation.

Keywords: toggle splint, coxofemoral luxation, nylon suture, lameness, radiograph

INTRODUCTION

Hip luxation is the most common form of joint luxation in pets, accounting for as much as 90% of all luxations (1). The majority of coxofemoral luxations (CFL), approximately 79% to 83%, are caused by vehicular trauma (2). Other causes include falls, hip dysplasia, and spontaneous luxations (3). In many traffic accident cases, traumatized animals suffer from multiple injuries, such as complete or comminuted fractures of the femur. These fractures can be treated by intramedullary pinning (4), bone plate and screws, and bone grafting (5). Additionally, several researchers recommend using different biomaterials, such as platelets-rich fibrin (PRF) or low-power laser, to enhance the healing of fractured bones and injured cartilage (6,7).

Craniodorsal is the most common type of luxation, occurring in 73% to 96% of cases (2). Caudoventral, cranioventral, and bilateral luxations have also been described, but with a lower frequency in dogs and cats (8).

Treatment options for hip luxations are either closed or open methods. Closed reduction is used for treating acute cases of luxation but is associated with a high rate of reluxation (9). Open reduction techniques include capsulorrhaphy, transarticular pinning, toggle pin fixation, fascia latae loop stabilization, transposition of the greater

trochanter, prosthetic capsule reconstruction, triple pelvic osteotomy, excision arthroplasty, and total hip replacement (10).

Toggle splint fixation is considered the best method for treating CFL as it provides a functional replacement of the round ligament of the head of the femur and ensures durable physiological coxofemoral stability (11). This method involves replacing the ligament of the head of the femur with one or two strands of suture between the femur and the acetabulum until joint capsular healing and periarticular fibrosis occur (12).

Various materials have been used to anchor toggle splints, including braided polyester (13), braided polyblend Tightrope (8), and nylon (13), with differing outcomes.

Nylon sutures are a type of non-absorbable suture made from a polyamide polymer. Nylon has very good tensile strength and loses 30% of its tensile strength within 2 years of implantation, causing minimal tissue reaction (14).

The objective of this study is to evaluate the clinical and radiological efficacy of using a modified toggle splint with nylon suture in the stabilization of induced coxofemoral luxation.

MATERIALS AND METHODS

Ethical Approval

The experimental design and procedures carried out in this study were reviewed and approved in accordance with animal welfare ethical standards by the Research Ethics Committee at the University of Baghdad's College of Veterinary Medicine with ethics number 949/P.G. dated on April 26, 2022.

Animals and Experimental Design

Experimental animals and their management, the procedure followed for modification of toggle splint, and techniques to reduce and fix the coxofemoral luxation, including preoperative and postoperative care, were previously described in detail (**AL-Samarrai and AL-Timmemi, in press)**. Briefly, apparently, healthy adult mongrel dogs (n=5), weighing 15±2 kg, were used in the study. All experimental animals were clinically examined and housed under the same management conditions in the animals' cages located at the Department of Surgery and Obstetrics, College of Veterinary Medicine, University of Baghdad, Baghdad, Iraq. The animals were kept in their cages for 2 weeks for acclimatization. They dewormed with Drontal® Plus (BAYER, Germany).

Modified Toggle pin was made from a Steinmann pin (2 mm diameter and 1 cm length) by drilling a hole in the center using a bur (0.5 mm). Passing nylon monofilament suture (Acufirm, Germany) of size USP 2 through this hole (Figure 1).

All experimental animals were withheld food for 8 hours and water for 2 hours before surgery. Atropine sulphate (Advacare, USA) as preanesthetic at a dose of 0.02 mg/kg BW was injected intramuscularly followed by intramuscular injection of a mixture of 1-2 mg/kg BW xylazine hydrochloride (Alfasan, Holland) and 10-20 mg/kg BW of ketamine hydrochloride (Alfasan, Holland) (15). After preparation of the surgical site aseptically a craniolateral incision was made to approach the craniodorsal aspect of the hip joint (16). After drilling a femero-acetabular tunnel that began at the third trochanter and exits at the fovea capitis and the acetabular fossa. The acetabular hole was used to insert the toggle splint, which was then pushed to the medial side. While the hip is being reduced to its natural position, the sutures were drawn through the tunnel and kept taut. Then, a second hole was made from the cranial side of the femur to the caudal side. This hole was used to insert both pairs of sutures, which were secured on the lateral side of the femoral cortex. Mattress sutures were placed to the joint capsule then muscles. Simple continuous suturing of subcutaneous tissue, and skin were closed with 3-0 polydioxanone subcuticular technique.

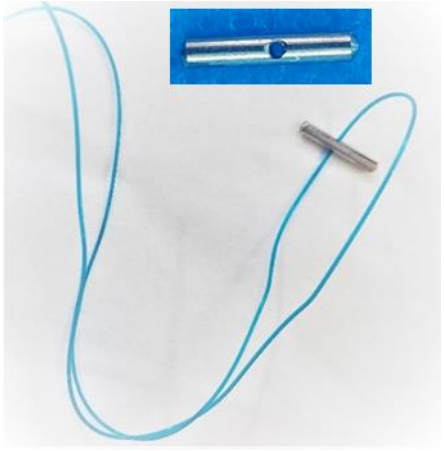

Figure 1. A photograph of a modified toggle splint with nylon suture

Lameness Score

On day 0, 14 and 42, lameness scoring forms employed a numeric rating scale (NRS) with 0-5 scale of lameness severity (8) (Table 1).

Table 1. Lameness scores

Score	Criteria
0	normal gait
1	mild weight-bearing lameness
2	moderate weight-bearing lameness
3	severe weight-bearing lameness
4	severe intermittent weight-bearing lameness (carries limb when trotting).
5	severe continuous non-weight bearing lameness

Each score has a certain clinical sign in which 0 = the animal walking normally, 1 = intermittent lameness at trot

and gallop without limb elevation, 2 = lameness at trot and gallop with total weight limb bearing, 3 = lameness at walking and trot with partial weight bearing with elevation of the limb at gallop, 4 = Infrequent and intermittent support of the limb, and 5 = no limb use and no weight bearing (17).

Radiographic Observations

The animal was placed in dorsal recumbency with the hindlimbs drawn caudally and as nearly parallel to each other and to the tabletop as possible. The extended hindlimbs are rotated inward. A ventrodorsally view at three periods postoperatively taken at the day of surgery (day 0), and on the 28th and 42nd day following surgery in all cases. Radiographic evaluation was performed using a digital radiograph (Pixxgen Corporation, Korea, Model PIXX1717) at exposure factors of 70-75 kVp and 10 mA/sec (mAs), with a source-to-image distance of 90 cm. Clinical examinations, which included lameness, pain, range of motion, and crepitation assessment were also performed during the time of the radiological evaluations.

Postoperative Care

Amoxicillin (Zoetis, USA) at dose of (22 mg/kg BW twice daily) and Ketoprofen (Vetanco, Argentina) at dose of 0.2 mg/kg BW were given intramuscularly to all animals for five consecutive days. Ehmer sling was not applied in either animal and exercise was restricted to cage rest for 14 days in the cages. Additionally, the dogs were restricted to leash walks for one month.

Statistical Analysis

The changes in lameness scores over time were analyzed using a mixed-effects model for repeated measurements in JMP® Pro 16.0.0 statistical software (SAS, Institute Inc., Cary NC). The model included fixed effects for time and a random intercept for each dog to account for the correlation between repeated measurements taken on the same dog. The model utilizes restricted maximum likelihood (REML) estimation for variance components. The significance of the random effect was determined using the Wald test. Significant mean differences were calculated using Tukey's honestly significant difference (HSD) test. The Chi-squared ($\chi 2$) test was used to compare the proportion of good reductions and reluxation at three time points (the day of surgery, day 28th and 42nd) for the reduction data (18).

RESULTS

Lameness Score

The mixed-effects model analysis revealed a significant effect of time point on lameness scores (P = 0.001), indicating changes in lameness severity over time. Specifically, pairwise comparisons using the Tukey HSD test showed a significant decrease in lameness scores between day 0 and day 28 (P = 0.019), day 0 and day 42 (P = 0.001), but no significant difference between day 28 and day 42 (P = 0.122) (Table 2). The estimated least square means for lameness scores at day 0, day 28, and day 42 were 4.2±0.20, 2.0±0.84, and 0.60±0.60, respectively.

A total of 47.3% of the variation in lameness ratings was explained by the random intercept for each dog, while 52.7% was explained by the residual variance, as estimated by the variance components. This indicates that lameness scores varied, both between and within individual dogs. Nonetheless, since the Wald P-value for the random intercept was only 0.311 (Table 2), it is not possible to conclude that there is significant variability in lameness scores between dogs. The fit statistics (measures of the goodness of fit of a statistical model) for the mixed-effects model showed an Akaike Information Criterion corrected for small sample sizes (AICc) value of 62.25 and a Bayesian Information Criterion (BIC) value of 59.13, indicating a good fit of the model to the data.

Table 2. Mixed-effects model results for changes in lameness scores over time

Statistical Measure	Description	Result
Random Effect	Dog ID	47.3%
	Residual	52.7%
	Wald P-value for Random Effects	0.311
Fixed Effect Test (Time Point)	F-test significance	P = 0.001
Tukey HSD Comparisons	Day 0 vs Day 28	P = 0.019
	Day 0 vs Day 42	P = 0.001
	Day 28 vs Day 42	P = 0.122
Estimated Marginal Means	Day 0	4.2±0.20
	Day 28	2.0±0.84
	Day 42	0.60± 0.60
Fit Statistics	AICc	62.25
	BIC	59.13

AICc, Akaike Information Criterion corrected; BIC, Bayesian Information Criterion

Reduction

Median surgery time was 2 h and there were no signs of any complications. Four animals were able to weight bearing on the affected limb one day postoperatively. The radiological examination revealed a good reduction of four luxated animals (Figure 3 A-C) with no evidence of osteoarthritis along the period of the study. One animal had reluxation the next day after surgery which suffered from stiffness and disability in extending its limb normally after the end of experimental period and follow up a surgery of femoral head and neck was performed to reduce the luxated limb (Figure 4 A, B).

A Chi-squared test was used to analyze the reduction outcomes at the day of surgery (day 0), day 28th, and day 42nd in five dogs treated with a nylon suture with a modified toggle splint to fix coxofemoral luxation. Four out of five dogs had a good reduction, while one dog had no reduction.

There was no significant difference in the proportion of good reduction and no reduction between the three time points (*P*=0.67) (Table 3).

The use of nylon suture allows for an early return to function. After surgery, all dogs that were not placed in an Ehmer sling and they used the limb within the first 24 hours.

None of stabilized cases reported stiffness after exercise, and no cases reported the need for any medications for osteoarthritis related to the hip. Finally, 80% of cases reported an excellent result.

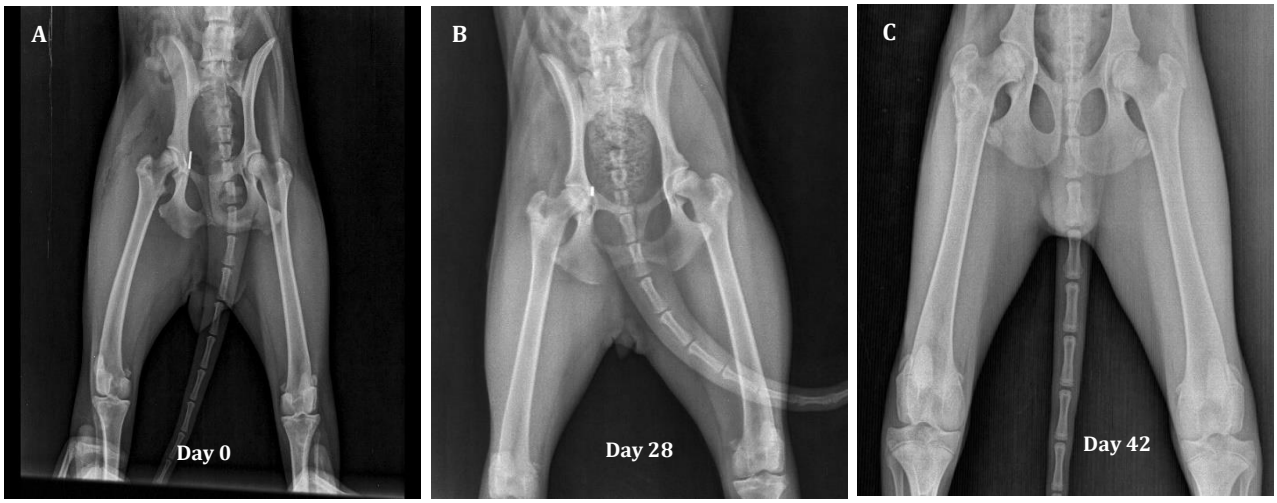

Figure 3. Representative postoperative radiograph of reduced cases at ventrodorsal view along the period of study

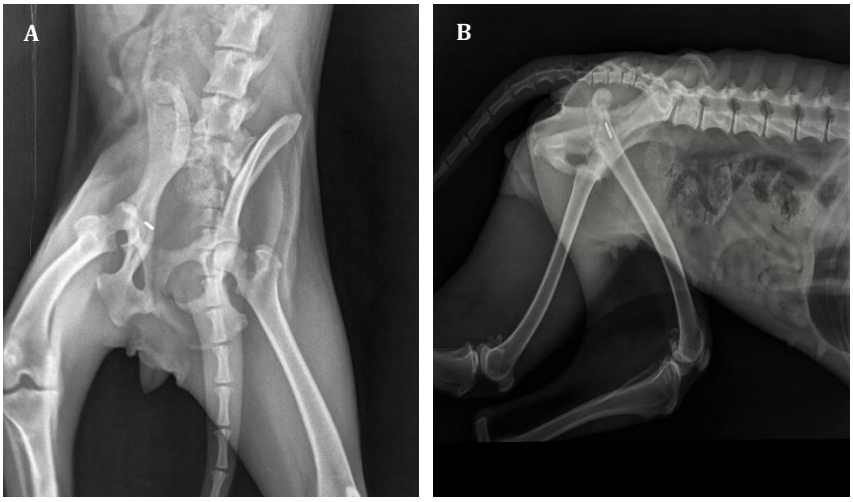

Figure 4. (A) ventrodorsal, **(B)** lateral radiographs of the reluxated case

Table 3. Reduction and reluxation rate in all animals at different time

		Reduction			
	n	Good		Reluxated	
Time Point		Number	%	Number	%
Day 0	5	4	80	1	20
Day 28	5	4	80	1	20
Day 42	5	4	80	1	20

DISCUSSION

Open reduction and stabilization of CFL by Toggle splint stabilization technique is indicated when rapid weight bearing on the luxated limb is required due to orthopaedic injury to the other limb (19).

Lameness is a clinical symptom that can be brought on by orthopaedic, oncological, or neurological diseases that affect the tissues necessary for appropriate movement and subjective gait analysis provides valuable information to assist in determining the affected limb and structures (20). While there was no statistically significant difference in

lameness scores between day 14 and day 42, it is important to note the substantial overall improvement in lameness severity observed over the entire study duration. A significant decrease of 3.6 points in lameness scores from day 0 to day 42 was achieved, indicating a considerable enhancement in limb function and a positive response to the surgical intervention with the modified toggle splint and nylon sutures. Furthermore, within the later stages of the recovery process, a decrease of 1.4 points in lameness scores from day 14 to day 42 was reported. Although this reduction was not statistically significant, it suggests a continued trend of improvement beyond the initial recovery period. It is expected that the lameness degree will be decreased more in the next weeks, based on previously reported studies which confirmed that 90% good to excellent recovery and had no or only negligible lameness at a minimum of 6 months after surgery (21).

The current study reported 4 animals (80%) of successful cases of CFL stabilized with hip toggle splint using the nylon suture, this ratio of success is the same as the finding of (22) which treated 128 cases of hip luxation in dogs with toggle rod stabilization using nylon monofilament suture. While the rest (20%) suffer from reluxation which is classified as a major complication (8), and it occurred due to knot failure as previously reported (21, 23, 25). Other researchers reported the same rate of reluxation, 11– 25%. (1, 9, 11, 22). In one study using tightrope system obtained the same results (26). This percentage of failure attributed to either breakage of the prosthetic ligament of femoral head, breakage of the toggle splint, femoral head fracture, and fracture of the femoral neck by the prosthetic material used (26, 27). Furthermore, other studies reported high rate of failure (43.5%) in dogs treated with closed reduction and Ehmer sling application with closed reduction (28). This shows the priority of using open reduction with toggle splint stabilization.

Implant position remains constant and femoral bone tunnel widening was not found in all dogs on postoperative radiographs along the period recheck examination. Widening may be attributed to an implant reaction and subsequent bone response, micromotion of the splint, or infection and it occurs when multifilament suture is used to anchor the splint, almost persistent, but not progressive (26). No signs of any infection were seen in all these cases. This considers an advantage to use nylon suture in fixation.

It is important to note that the number of animals of this study was relatively small, which may limit the power and generalizability of the statistical analysis. Future studies with larger sample sizes may be necessary to confirm these findings. Additionally, the use of clinical cases or smaller laboratory animals like rats could be considered to overcome the ethical concerns and limitations of laboratory animal utilization.

In conclusion, the results of this study suggest that modified toggle pin of size (1 cm 2 mm) was a successful and an effective method in stabilization of hip luxation. nylon sutures may be a good option for surgically treating femoral luxation in dogs, particularly in the long term. However, further research with larger sample sizes and longer follow-up periods is needed to confirm these findings and to evaluate the safety and cost-effectiveness of these types of sutures.

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N/A

CONFLICT OF INTEREST

The authors declare no conflict of interest.

EDITORIAL PROCESS TRANSPARENCY

Hameed A AL-Timmemi is the Editorial Board of The Iraqi Journal of Veterinary Medicine. Despite this role, the peer review process and the final publication decision were made independently and impartially, ensuring no influence from the author's editorial position.

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فاعلية استخدام جبيرة توكل مع خيط النايلون في تثبيت خلع مفصل الورك في الكلاب

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الخلاصة

خلع مفصل الورك هو اصابة شائعة في الكلاب. حيث هدفت هذه الدراسة إلى تقييم الجبيرة المكونة من الخيط النايلون مع دبوس مصنع من الستنلس ستيل كبديل للرباط المدور الفخذي لتثبيت خلع الفخذ في الكلاب. تم استخدام خمسة كلاب محلية بالغة تزن ١٥ ±٢ كجم في هذه الدراسة. تم تصنيع الجبيرة من دبوس تثبيت طوله ١ سم وقطره ٢ مم عن طريق حفر ثقب في المركز قطره ٠,٥ مم. كما تم تثبيت الطرف المخلوع عن طريق اجراء نفق من عظم الفخذ الى عظم الحوض وتمرير الجبيرة مع خيط النايلون عبرها. تمت متابعة الحيوانات لمدة ستة اسابيع شعاعيا في يوم العمليه واليوم الثامن والعشرين واليوم الثاني والاربعين وسريريا حيث تم تسجيل شدة العرج في اليوم الاول و الرابع عشر والثاني والاربعين بعد عملية التثبيت. اظهرت نتيجة الصور الشعاعية نجاح التثبيت في ٨٠٪ من الحالات طول فترة الدراسة. كما ان متوسط درجة العرج انخفض من ٢,٠ في اليوم ١٤ إلى ٠,٦ في اليوم ٤٢ مع اظهار فرق معنوي مقارنة مع اليوم الاول ($P<0.001$). تشير هذه النتائج إلى أن الجبيرة المصنعة مع خيوط النايلون هي خيار واعد لعلاج حالات خلع الفخذ في الكلاب.

الكلمات المفاحية: جبيرة توكل، خلع مفصل الورك، خيط النايلون، العرج، الصور الشعاعية