Hip Toggle Stabilization Using the TightRope® System in 17 Dogs: Technique and Long-Term Outcome

Nina R. Kieves[1], DVM, Peter J. Lotsikas[2], DVM, Diplomate ACVS & ACVSMR, Kurt S. Schulz[3], DVM, MS, Diplomate ACVS, and Sherman O. Canapp[4], DVM, MS, Diplomate ACVS & ACVSMR

[1] Iowa State University Lloyd Veterinary Medical Center, Ames, Iowa ,[2] Crossroads Animal Referral & Emergency, Frederick, Maryland ,[3] Peak Veterinary Referral Center, Williston, Vermont and [4] Veterinary Orthopedic & Sports Medicine Group, Annapolis Junction, Maryland

Corresponding Author
Peter J. Lotsikas, DVM, Diplomate ACVS & ACVSMR, Crossroads Animal Referral & Emergency, 1080 W. Patrick St., Frederick, MD 21703.
E-mail: plotsikas@yahoo.com

Submitted March 2012
Accepted January 2012

DOI:10.1111/j.1532-950X.2014.12158.x

Objective: To describe the technique for, and long-term clinical outcome of, a modified hip toggle stabilization using the TightRope® system for coxofemoral luxation repair.
Study Design: Retrospective case series.
Methods: Medical records (July 2008–July 2010) including radiographs (17 limbs) of dogs that had coxofemoral luxation repaired with the TightRope system were reviewed. Follow-up (≥12 months) was obtained by telephone interview of owners. Six dogs were available for re-evaluation, radiographs, and objective gait analysis.
Results: Follow-up (mean, 24 months; range, 12–43 months) by telephone interview was available for 17 dogs. Of these, 6 dogs were re-evaluated (mean, 7.5 months; median 12.5 months: range, 4–24 months) and had gait analysis. Mean duration of luxation before surgical intervention was 7.5 days (median, 7 days; range, 2–44 days). There was a single case of relaxation 27 months postoperatively. One dog died from non-surgical related circumstances. Objective gait analysis showed equal pelvic limb use in all 6 dogs available for re-evaluation. All owners of living dogs reported limb function as being good to excellent, and perceived that their dogs were pain free. Radiographs (mean, 7.5 months; median, 12.5 months; range, 4–24 months post surgery) of 6 dogs showed no progression of osteoarthritis in comparison to immediate postoperative radiographs.
Conclusions: Hip toggle with the TightRope system as a prosthetic ligament of the head of the femur produces a favorable clinical outcome with high owner acceptance.

Coxofemoral luxation (CFL) accounts for 90% of all luxations in dogs.[1–6] Most CFLs in dogs and cats are the result of external trauma, with vehicular trauma causing 59–83% of cases.[1,2,6–8] Craniodorsal CFLs comprise 78% of luxations.[2,3,6] Ventral luxation occurs in 1.5–3.2% of cases, and caudodorsal luxation is rare.[6]

Closed reduction is often attempted initially when there is little or no radiographic evidence of hip dysplasia. Closed reduction has a reported 47–65% failure rate for single attempts at reduction.[1,2,6] After closed reduction of craniodorsal luxation, it is recommended that the limb be placed in an Ehmer sling for 10–14 days to prevent reluxation.[3,4,9] When a closed reduction fails, or there are concurrent orthopedic injuries (pelvic fractures, intra-articular fractures) that require immediate weight bearing, open reduction with stabilization, total hip arthroplasty, triple pelvic osteotomy or femoral head and neck ostectomy (FHO) is warranted. Numerous techniques for open reduction and stabilization of the hip have been described including capsulorrhaphy, DeVita pinning, placement of extracapsular sutures, tenodesis of the deep gluteal muscle, transarticular pinning, transposition of the greater trochanter of the femur, transposition of the sacrotuberous ligament, and toggle rod stabilization.[3,5,8,10–29]

Complications of open reduction include reluxation, infection, implant migration or failure, neurologic damage, and injury to the articular cartilage.[1,5,7] In toggle rod stabilization, the goal is to replace the ligament of the head of the femur (LHF) with a synthetic prosthesis that will maintain reduction of the coxofemoral joint allowing for the joint capsule to heal and scar tissue to form.[6] The procedure has been described using many variations of prosthetics to act as the LHF including absorbable and non-absorbable suture material.[5,17] Reluxation rates are variable and are reported to occur in 11–25% of cases with toggle rod stabilization.[1,5,7,30]

Our objectives were to describe the technique of hip toggle stabilization using the TightRope® system as the prosthetic

Work performed at Veterinary Orthopedic & Sports Medicine Group and at Peak Veterinary Referral Center.
Presented in part at the 38th Annual Conference of the Veterinary Orthopedic Society, Snowmass, CO, March 5–12, 2011, and at the Annual American College of Veterinary Surgeons Veterinary Symposium, Chicago, IL, November 4–7, 2011.

LHF for open reduction of CFL, and report the long term clinical outcome and complications in 17 dogs.

MATERIALS AND METHODS

Inclusion Criteria

Medical records (July 2008–July 2010) of 22 dogs with coxofemoral luxation that had hip toggle stabilization with the TightRope system performed at 2 private practices were retrospectively reviewed (Table 1). Dogs were excluded if a complete medical record was not available for review, if the dog had concurrent neurologic disease, or if the dog had concurrent implants placed in addition to TightRope hip toggle stabilization for surgical repair of coxofemoral luxation. Each dog's signalment and pertinent medical history, including existing orthopedic disease such as hip dysplasia, concurrent injuries, and length of time from injury to hip toggle stabilization, were recorded. Radiographs were obtained in all dogs before surgery to determine the extent of injury, immediately postoperatively, and at 4 weeks postoperatively to assess for reluxation and development of osteoarthritis.

Anesthesia

Dogs were premedicated with diazepam (0.4 mg/kg) and hydromorphone (0.1 mg/kg) intravenously [IV], induced with propofol (2–4 mg/kg IV) and maintained with isoflurane in oxygen for the duration of the procedure. Dogs 1, 2, 6–8, 10–12, and 18–21 were also administered epidural, preservative-free, morphine (0.1 mg/kg) at the L7-S1 intervertebral space.

Surgical Procedure

The affected hip was aseptically prepared for surgery using a hanging-limb technique. Perioperative cefazolin (22 mg/kg IV) was administered 20–30 minutes before the incision and then every 90 minutes until completion of surgery. A board-certified surgeon performed all surgeries. A standard craniolateral approach to the coxofemoral joint was performed. A partial tenotomy of the deep gluteal tendon was made at the insertion site along the greater trochanter. The articular cartilage of the femoral head and acetabulum were thoroughly evaluated and the acetabular fossa was debrided of ligament.

A hole was drilled through the acetabular fossa using either a 3.5 mm drill bit or 2.7 mm drill bit, corresponding to either the regular TightRope system or the mini TightRope system. Next, a femoral bone tunnel was started with a 1.2 mm guide wire at the fovea capitis and exited laterally on the proximal femur at the location of the third trochanter (Fig 1). Once the correct orientation of the guide wire was confirmed, the guide wire was over drilled with an appropriate cannulated drill bit. The femoral tunnel was no >20% of the width of the femoral neck (see Table 2 for appropriate drill size based on weight).

Table 1 Summary of Signalment and Outcome

					Luxation			
Case	Breed	Sex	Age (year)	Body Weight (kg)	Direction	Duration (days)	Final Evaluation	Previous Treatment
1	Golden Retriever[*]	MI	4.4	37.3	CD-L	5	Good	None
2	American Eskimo	MN	10.1	17.3	CD-L	10	Excellent	Closed reduction
3	Pit Bull Mix[†,*]	MN	2.3	38.1	CD-L	2	Excellent	None
4	German Shepherd Dog	FS	4.0	29.6	CD-L	3	Excellent	Multiple closed reductions
5	Miniature Poodle	MI	8.1	5.0	CD-L	8	Reluxated	Closed reduction
6	Samoyed	FI	8.0	18.5	V-R	5	Excellent	2 closed reductions
7	Pug[‡]	MN	10.0	8.1	CD-R	2	Excellent	None
8	Belgian Tervuren	FS	11.5	20.5	CD-L	20	Excellent	None
9	Cocker Spaniel	MN	10.0	14.4	CD-L	10	Excellent	2 closed reductions
10	Pyrenean Shepherd	FI	7.9	6.3	CD-L	7	Excellent	2 closed reductions
11	Shih-Tzu[§]	MN	10.0	7.9	CD-R	7	Excellent	None
12	Pomeranian	FS	10.2	2.7	CD-R	15	Excellent	None
13	Border Collie	FS	9.2	14.7	V-L	44	Excellent	Closed reduction
14	Mix Breed[¶]	MN	4.5	27.6	CD-R	4	Excellent	None
15	Labrador Mix[‖]	FS	10.0	40.0	L	4	Excellent	None
16	Springer Spaniel	MN	2.0	21.8	R	5	Excellent	None
17	Labrador	FI	2.2	45.5	CD-L	7	Excellent	Closed reduction

MN, male neutered: FI, female intact: MI, male intact: FS, female spayed: CD-L, craniodorsal left sided: CD-R, craniodorsal right sided: V-L, ventral left sided: I, grade of lameness at presentation (score I–IV), II time from surgery to end of visible lameness in weeks per owner.

[*]Concurrent injury = left medial tibiotarsal instability (no treatment).

[†]Concurrent injury = right tibial fracture (external fixator placed at time of surgery).

[‡]Concurrent injury = left sacroiliac luxation (lag screw placed at time of surgery) and multiple pubic and ischial fractures.

[§]Concurrent injury = left sacroiliac luxation (lag screw placed at time of surgery).

[¶]Concurrent injury = left sacroiliac luxation (no instability, no repair).

[‖]Concurrent bilateral medial patellar luxation.

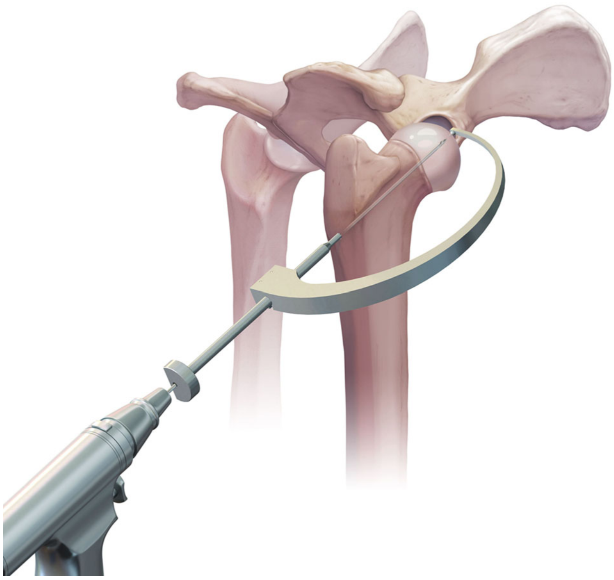

Figure 1 A 0.045 Guidewire is placed from the third trochanter to the fovea capitis. This can be placed in a retrograde fashion or normograde with the aid of an aiming device. (Image courtesy of Arthrex Vet Systems).

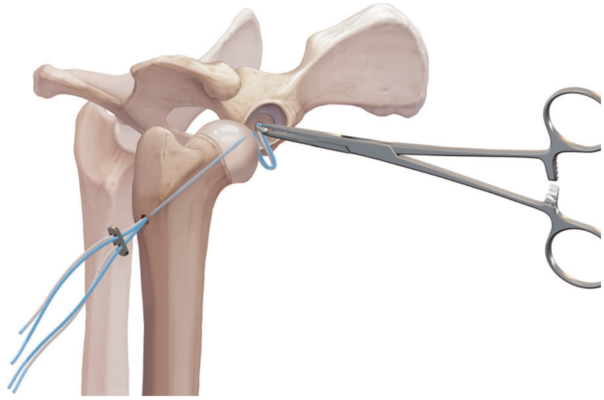

Figure 2 The toggle button is grasped with a curved hemostat and advanced into the acetabular hole. The toggle is pushed completely through the hole and the FiberTape strands are pulled on to allow the toggle button to flip and seat firmly on the medial wall of the acetabulum. (Image courtesy of Arthrex Vet Systems).

When the standard sized TightRope system drill bit was used for the femoral tunnel, the swaged TightRope needle was inserted through the femoral hole from the third trochanter to the location of the fovea capitus. Tension was applied to the needle and FiberTape to advance the toggle button through the femoral neck tunnel. The 2nd button was left on the third trochanter.

The needle was cut free from the toggle button. Then the toggle button was grasped on end with a curved hemostat and advanced into the acetabular hole (Fig 2). The blunt end of the cut needle was used to push the toggle through the hole, and gentle tension was then applied to the FiberTape to flip the toggle button, and seat it on the medial wall of the acetabulum.

Slack was removed from the FiberTape as the femoral head was reduced into the acetabulum to ensure proper orientation (Fig 3). The FiberTape was tied over the button located at the third trochanter using mild tension (4 throws). The limb was held in a neutral position while tying the FiberTape.

The hip was placed through a gentle range of motion to assess for impingement before cutting the suture ends (Fig 4). The joint capsule was closed when enough tissue was present, followed by closure of the deep gluteal tendon, lateral fascia, and superficial tissue layers.

In smaller animals, a 2.0 cannulated drill bit was used to drill the femoral hole. In these cases, the TightRope was placed in reverse order, since the toggle button would not fit through the femoral tunnel. The acetabular toggle was implanted and seated first, as previously described. The blunt end of a nitinol loop was placed through the femoral tunnel from the fovea to the third trochanter. The nitinol loop was used to pull 1 set of suture strands through the femoral tunnel at a time. In dogs <7 kg, only a single strand of FiberWire was used.[31]

Postoperative Care

Dog 2, and 4–6 had an Ehmer sling applied for 2 weeks postoperatively, all other dogs were allowed to bear weight on the surgical limb immediately after surgery. All dogs were discharged on a 5–10 day course of cephalexin (22 mg/kg orally twice daily) or enrofloxacin (10 mg/kg per orally once daily), and either a non-steroidal anti-inflammatory drug and/or tramadol (2–4 mg/kg orally every 8 or 12 hours) for pain relief. Activity was restricted for 3 months; initially dogs were confined in a small area, with leash walks for elimination only, and a belly sling as needed for support for 1 month

Table 2 Guide to Drill Bit and Implant Size Based on Dog Weight

Dog Weight	Implant Size	Drill Bit Size
<20 lbs	Mini TightRope®	2.7 mm for the acetabulum and 2.0 mm for the femoral neck*
20–50 lbs	Mini TightRope®	2.7 mm
>50 lbs	Standard TightRope®	3.5 mm

*This requires the toggle button to be placed through the medial wall first, and then the FiberWire is passed through the femoral tunnel using the Nitinol Suture Passing Wire, blunt tip first.

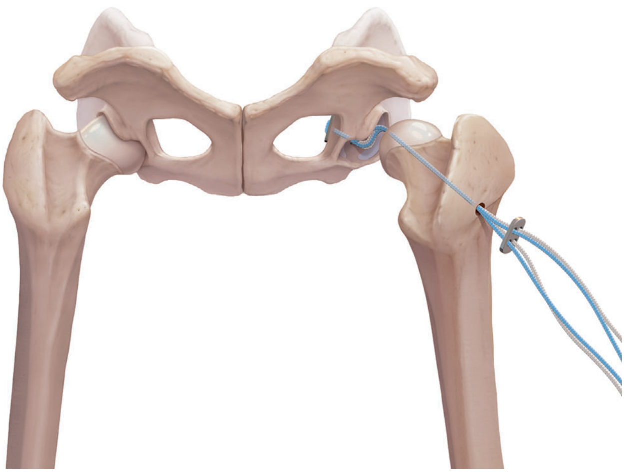

Figure 3 The slack is removed from the FiberTape as the femoral head is reduced into the acetabulum to ensure the femoral head is properly oriented. (Image courtesy of Arthrex Vet Systems).

postoperatively. One month postoperatively dogs began leash walks of increased duration with no sling support; and 2 months postoperatively dogs were allowed increased activity, but still limited to on-leash activity. In addition, owners were given a home exercise program, which included range of motion type exercises as well as muscle strengthening exercises. Rehabilitation therapy with a certified therapist was also recommended. Dogs 3 and 7 received additional rehabilitation therapy for concurrent orthopedic injuries (Table 1).

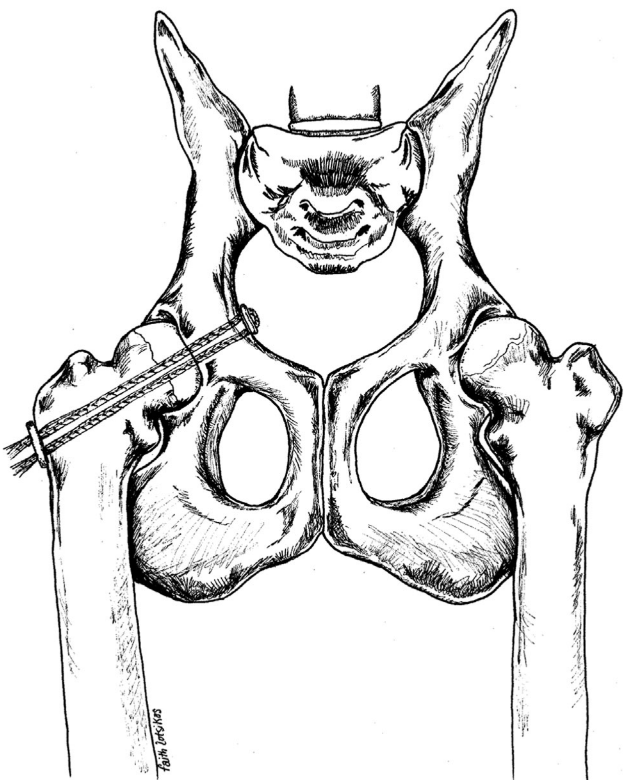

Figure 4 Illustration of correct anatomic placement of the FiberTape.

Outcome

Medical records and radiographs obtained at the time of surgery, and 4 weeks after surgery were reviewed. At 4-week follow-up all dogs were examined and evaluated for lameness by a veterinarian. A lameness score of 0–IV was assigned to each dog for the surgically repaired limb (0 = no lameness, 1 = intermittent lameness, 2 = consistent weight-bearing lameness, 3 = intermittent non-weight bearing lameness, 4 = non-weight bearing lameness). Follow-up (mean, 24 months; median, 24 months; range, 12–43 months) was obtained by telephone interview of owners. A standard questionnaire of 6 questions was used (Table 3). Owner assessment of postoperative complications, lameness, pain, and return to function at home, as well as overall satisfaction with the outcome of the surgery was evaluated.

Six dogs returned for long-term recheck evaluation as part of the questionnaire (mean, 7.5 months; median, 12.5 months; range, 4–24 months). Evaluation included physical exam, pelvic radiographs, and assessment with a temporal-spatial gait analysis walkway system with a 5.5-m × 0.85-m portable matt with 18,432 encapsulated sensors (GAIT Rite, platinum version, CIR Systems Inc, Havertown, PA). Digital video files of the walks were used to verify footfall of the walks. A software program (GAITFour software, version 40f, CIR Systems, Inc) was used to obtain data including stance time,

Table 3 Owner Questionnaire

Immediate Postoperative
- 1) Did your pet require additional veterinary care for incision care or additional pain relief?

Long Term
- 2) Does your dog exhibit lameness when walking?
  - a. If no, when did your dog stop showing lameness?
    - i. 1 month postoperatively
    - ii. 2 month postoperatively
    - iii. 3 month postoperatively
    - iv. 4 month postoperatively
  - b. If yes, is it better or worse than it was before surgery?
- 3) When did your dog begin to bear weight on the limb postoperatively?
  - a.<1 week postoperatively
  - b. 1–2 weeks postoperatively
  - c. 2–4 weeks postoperatively
  - d. >4 weeks postoperatively
- 4) Does your dog experience stiffness when arising for the day?
- 5) Does your dog experience stiffness at the end of the (after activities)?
- 3) How would you rate the outcome of the surgery?
  - a. 0–excellent (no lameness)
  - b. 1–good (occasional lameness)
  - c. 2–ok (regular lameness)
  - d. 3–poor (always lame)

stride length, mean pressure index, and symmetry ratios of left limbs to right limbs and thoracic to pelvic limbs.

RESULTS

Twenty-two dogs met the initial criteria for study inclusion. One dog was excluded because of concurrent neurologic disease localized to the brain stem. Four other dogs were excluded because they had additional stabilization in the form of an antirotational suture (bone anchor in the caudal ilium with #2 Fiberwire from the anchor to a hole in the greater trochanter) placed at the time of open reduction.

Hip toggle stabilization using the TightRope system was achieved successfully in 16 dogs (Table 1). Success was defined as either a good or excellent outcome without reluxation (Table 3). Mean age of dogs was 5.9 years (median, 8.1 years; range, 2.0–11.5 years) and mean weight was 17.0 kg (median, 18.5 kg; range, 2.7–45.5 kg). Nine dogs were male (2 intact) and 8 were female (3 intact). Breeds represented included 1 each of American Eskimo, Belgian Tervuren, Border Collie, Cocker Spaniel, German Shepherd Dog, Golden Retriever, Labrador Retriever, Labrador Retriever Mix, Miniature Poodle, Pit Bull Mix, Pomeranian, Pug, Pyrenean Shepherd, Samoyed, Shih-Tzu, Springer Spaniel, and 1 mixed breed.

All dogs had traumatic hip luxations: 12 dogs had vehicular trauma and concurrent orthopedic injuries. Dog 1 (Table 1) had left medial tibiotarsal instability that was treated without surgical stabilization. Dog 3 had a tibial fracture of the contralateral limb that was repaired using a type Ib linear external fixator. Dog 7 had a sacroiliac luxation (SI) of the contralateral limb, and multiple pubic and ischial fractures. The SI luxation was repaired using a single 3.5 mm cortical screw spanning 60% of the sacral width.

Dogs 10 and 11 had bilateral mild hip dysplasia (adequate dorsal acetabular rim coverage, mild incongruency, with minimal degenerative changes). Dog 12 had concurrent bilateral medial patellar luxations (both grade II/IV). Dog 13 had moderate degenerative changes of the contralateral hip, which had traditional toggle rod stabilization 24 months previously.

Mean duration from luxation to surgical reduction was 7.5 days (median, 7 days; range, 2–44 days). Nine dogs (53%) had failed attempts at closed reduction before surgery. Four of 9 had multiple failed attempts at closed reduction. Two major complications occurred, dog 4 had dehiscence of the incision that required surgical repair, and dog 5 had reluxation of the hip 27 months postoperatively.

A veterinarian evaluated all dogs 4 weeks after surgery and the degree of lameness at that time was graded as a 0–I/IV. The 6 dogs available for mid to long-term follow-up (range, 4–24) months) were all assessed to have normal range of motion, and pain free extension and abduction of the surgically repaired hip. Radiographs in these 6 dogs revealed stable implants with minimal to no progression of periarticular osteophytosis of the surgical hip compared with the immediate postoperative radiographs. Static implant position and mild uniform femoral bone tunnel widening was seen in all dogs on postoperative radiographs at the 1 month recheck examination. Tunnel widening was unchanged at long-term follow-up for all 6 dogs. Minor subsidence of the lateral button was noted in dog 2 re-evaluated for long-term follow-up (Fig 5).

Phone interview/questionnaire follow-up (mean, 24 months; median, 24 months; range, 12–43 months) was available for all 17 dogs. Fifteen (88%) owners reported limb function as being excellent (no lameness) with no stiffness in the morning or after exercise. The remaining owners (12%) reported a good outcome. One of these dogs, dog 1, had a concurrent left medial tibiotarsal instability that was not stabilized surgically. This dog was administered a non-steroidal anti-inflammatory for pain relief as needed. Dog 5 had hip reluxation 27 months postoperatively. Until reluxation this owner assessed outcome of surgery as excellent, with no discomfort in the hip noted. All owners perceived that their dog's postoperative pain was well managed in the perioperative period, and would have the procedure performed again for a similar injury.

Temporal-spatial gait analysis performed on dogs 3, 5, 10–12, and 14 showed normal symmetry ratios between the thoracic and pelvic limbs, as well as symmetry between left hind and right pelvic limbs. There was a $<5\%$ difference in stance time and mean pressure index between the operated and non-operated pelvic limb.[32]

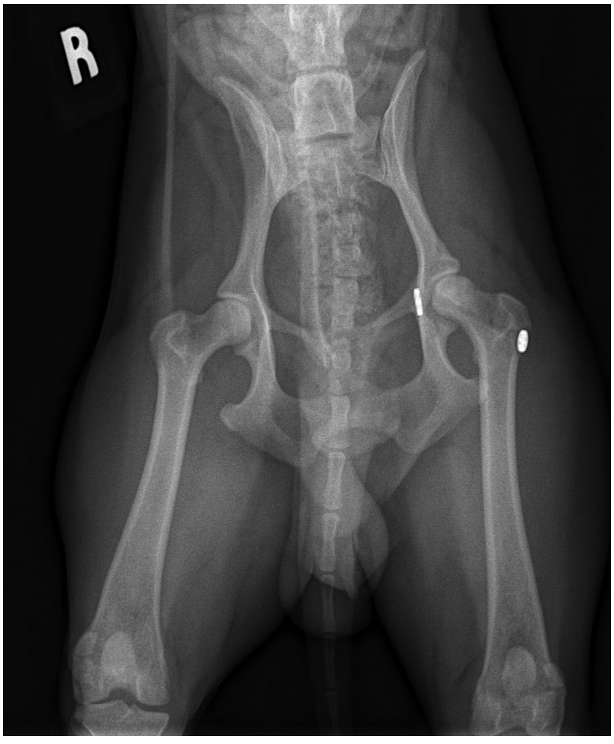

Figure 5 Ventrodorsal radiographs made of dog 2, 21 months after surgery. Mild subsidence of the lateral button and tunnel widening is present. There is no radiographic evidence of osteoarthritis.

DISCUSSION

Open reduction and stabilization of CFL is indicated when closed reduction fails, or in cases where immediate weight bearing on the luxated hip is necessary because of concurrent orthopedic injury in the contralateral limb. Many surgical techniques have been described for open reduction including intra and extra-articular stabilization methods.[5,10,12–30] Of the reported procedures, no single technique has proven superior to another in terms of technical ease, complication rates, or long-term outcome. We report 16 cases of successful stabilization of CFL with hip toggle stabilization using the TightRope system, including dogs with ventral luxations and large breed dogs.[31,33] The use of the TightRope system for toggle stabilization has also been reported with excellent outcome in cats and small breed dogs (<15 kg).[31,33,34]

Previously reported complications of toggle rod stabilization include reluxation after breakage of the prosthetic ligament of the head of the femur, reluxation after breakage of the toggle rod or pin, fracture of the femoral head, and fracture of the femoral neck by the prosthetic material used.[35,36] In our study the complication rate was 11.8%; both were classified as major complications.[37] One dog had dehiscence of the incision requiring re-suturing, and the other dog had reluxation of the hip after breakage of the prosthetic LHF 27 months postoperatively (dog 5).

The reluxation rate was 5.8%, which is lower than that previously reported for the toggle rod technique, 11–25%.[1,5,7,30] The owner of dog 5 reported that the dog did very well and had an excellent outcome until re-luxation, and that the dog had continued to perform in competitive obedience and agility trials before reluxation. At revision surgery, FHO was performed. At the time of FHO, minimal periarticular fibrosis was noted. An underlying metabolic condition was not identified to explain this deficiency. Neither the head of the femur, nor the surrounding soft tissues were submitted for histopathology, so no definitive underlying cause for the lack of development of the fibrosis was determined. The TightRope FiberTape appeared to have broken at the tunnel edge of the femoral head. Radiographically, both the medial and lateral toggle buttons were still in place. Grossly, the head of the femur did not have marked cartilage wear, suggesting that the femur was well seated in the acetabulum until reluxation.

Few studies have been performed to determine what material may be best suited as a prosthetic replacement for the LHF. Use of various materials including braided, woven, and monofilament material have been reported. One biomechanical study found no difference in load sustained in # 2 braided polyester versus 50 lb test monofilament nylon.[36] Another showed that woven polyester was significantly stronger than braided polyester or monofilament polybutester with a higher mean yield load.[35] We are unaware of published reports on the biomechanical properties of TightRope FiberTape suture for use in hip toggle stabilization; however, FiberTape suture and FiberWire suture have been compared to 4 suture systems used in cranial cruciate ligament rupture repair including 80 lb test monofilament leader line. *In vitro* testing found the TightRope FiberTape suture to be mechanically superior to the other suture materials tested. FiberWire was shown to be superior to #80 monofilament leader line, but not to FiberTape.[38] Another study found FiberTape and FiberWire to be stronger, stiffer, and have less elongation than nylon leader line *in vitro*.[39] Another study showed polyblend sutures, including FiberTape and FiberWire, to be stronger and elongate less than monofilament nylon leader line in pure tension.[40] This increased biomechanical strength may lead to a decreased reluxation rate; however, biomechanical studies directly comparing commonly used materials are needed to determine if one material is superior to another for toggle rod stabilization.

Previous studies comparing biomechanical strength of commercially available toggle rods and bone anchor fixation revealed that they are equal in their load to failure.[41] In addition, toggle rods and toggle pins have been shown to have similar mechanical properties when tested *in vitro*.[35] Whereas no biomechanical testing has been done looking specifically at the TightRope system in hip toggle repair of CFL, no failure of the toggle button was observed in any of these dogs; this is an area for future research.

Static implant position and mild femoral bone tunnel widening was seen in all dogs on postoperative radiographs at the 1 month recheck examination. The tunnel widening was symmetrical in all cases. This widening was persistent, but not progressive, in the 6 dogs available for >4 month re-evaluation. Widening could be attributed to an implant reaction and subsequent bone response, micromotion of the implant, or infection. Whereas braided non-absorbable suture has been reported to have a higher rate of infection than monofilament material, no evidence of infection was seen in any of these dogs. Minor subsidence of the lateral button was noted in 1 dog in which radiographs were available (Fig 5). A tensioning device was not used in any of these dogs, and the subsidence of the button could be attributed to over tightening of the implant. The clinical significance of these findings is unknown, but would suggest that the suture material itself remained intact. Retrieval of the implant material with the exception of the acetabular toggle would be technically feasible, but did not appear to be warranted in the dogs reported here, as none had signs of discomfort or lameness associated with the hip that underwent toggle rod stabilization (excluding dog 5 who ultimately developed a reluxation).

Fixation using TightRope FiberTape suture and button allowed for early return to function. All dogs not placed in an Ehmer sling postoperatively used the limb within the first week of surgery. All but 1 owner reported no noticeable lameness within 2 months of surgery.

Our survey found that all owners were extremely satisfied with the outcome and would have the surgery performed again. None of the owners reported stiffness in their dog in the morning or after exercise, and no owners reported the need for any medications for osteoarthritis related to the hip. Three dogs used for performance dogs competed successfully, a goal for these owners before surgery. One dog was able to compete at a national level 4 months postoperatively. Temporal-spatial gait analysis performed in 6 dogs >4 months after surgery objectively showed no difference in symmetry of left versus right pelvic limb at a walk. Two of these dogs were evaluated >20 months after surgery. None of the 6 dogs with long-term re-evaluation showed signs of progressive osteoarthritis on radiographs in comparison to immediate postoperative radiographs or in comparison to the contralateral hip (Fig 5).

Limitations of this study include the retrospective nature of our study, including reliance on the completeness of records. Surgical technique was similar, though not uniform in all dogs. Furthermore, only a small number of dogs were available for objective assessment of long-term outcome with in person evaluation with radiographs. All owners responded to a questionnaire regarding long term out come and although 88% reported an excellent outcome, the questionnaire has not been validated. Finally, no blinded review of radiographic progression of osteoarthritis was performed.

Limitations of the case series by Ash et al.[36] were a lack of long of long-term follow up, and homogenous population of small breed dogs and craniodorsal luxations. Based on the results of our dogs, we believe that the use of the TightRope system as a LHF prosthesis in a modified toggle rod stabilization is an effective technique for stabilization of CFL in large and small breed dogs with either craniodorsal or ventral luxations. Additionally, studies to evaluate the implication of tunnel widening, residual strength of the implant, and subsequent effect on joint health may be warranted. Future studies could include direct biomechanical comparison between FiberTape, FiberWire, and other commonly used materials in hip toggle stabilization.

DISCLOSURE

Drs. Lotsikas and Schulz are paid consultants for Arthrex Vet Systems; however, none of the authors have a proprietary interest in this procedure. No financial support or materials were provided.

REFERENCES

1. Bone DL, Walker M, Cantwell HD: Traumatic coxofemoral luxations in dogs, results of repair. *Vet Surg* 1984;13:263–270
2. Basher AWP, Walter MC, Newton CD: Coxofemoral luxation in the dog and cat. *Vet Surg* 1986;15:356–362
3. Fox SM: Coxofemoral luxations in dogs. *Compend Contin Educ Pract Vet* 1991;13:381–389
4. McLaughlin RM Jr: Traumatic joint luxations in small animals. *Vet Clin North Am Small Anim Pract* 1995;25:1175–1196
5. Demko J, Sidaway B, Thieman K, et al: Toggle rod stabilization for treatment of hip joint luxation in dogs: 62 cases (2000–2005). *J Am Vet Med Assoc* 2006;229:984–989
6. Piermattei DL, Flo GL, DeCamp CE: The Hip Joint, in *Brinker, Piermattei, and Flo's Handbook of small animal orthopedics and fracture repair* (ed 4). St. Louis, MO, Saunders Elsevier, 2006, pp 461–475
7. Duff SR, Bennett D: Hip luxation in small animals: an evaluation of some methods of treatment. *Vet Rec* 1982;111:140–143
8. Evers P, Johnston GR, Wallace LJ, et al: Long-term results of treatment of traumatic coxofemoral joint dislocation in dogs: 64 cases (1973–1992). *J Am Vet Med Assoc* 1997;210:59–64
9. Harasen G: Coxofemoral luxations part 1: diagnosis and closed reduction. *Can Vet J* 2005;46:370
10. Knowles AT, Knowles JO, Knowles RP: An operation to preserve the continuity of the hip joint. *J Am Vet Med Assoc* 1953;123:508–515
11. Fry PD: Observations on the surgical treatment of hip dislocation in the dog and cat. *J Small Anim Pract* 1974;15:661–670
12. Douglas IH: Modified De Vita pinning technique for the management of canine hip luxation: preliminary findings. *Aus Vet J* 2000;78:538–542
13. McLaughlin RM Jr, Tillson DM: Flexible external fixation for craniodorsal coxofemoral luxations in dogs. *Vet Surg* 1994;23:21–30
14. Martini FM, Simonazzi B, Del Bue M: Extra-articular absorbable suture stabilization of coxofemoral luxation in dogs. *Vet Surg* 2001;30:468–475
15. Shani J, Johnston DE, Shahar R: Stabilization of traumatic coxofemoral luxation with an extra-capsular suture from the greater trochanter to the origin of the rectus femoris. *Vet Comp Orthop Traumatol* 2004;17:12–16
16. Venzin C, Montavon PM: Augmentation of the transverse acetabular ligament in canine caudoventral hip luxation. *Vet Comp Orthop Traumatol* 2007;20:320–323
17. Lubbe AM, Verstraete FJM: Fascia lata loop stabilisation of the coxofemoral joint in the dog and cat. *J Small Anim Pract* 1990;31:234–238
18. Bjerring Mehl N: A new method of surgical treatment of hip dislocation in dogs and cats. *J Small Anim Pract* 1988;29:789–795
19. Johnson ME, Braden TD: A retrospective study of prosthetic capsule technique for the treatment of problem cases of dislocated hips. *Vet Surg* 1987;16:346–351
20. Rochereau P, Bernard A: Stabilization of coxo-femoral luxation using tenodesis of the deep gluteal muscle. *Vet Comp Orthop Traumatol* 2012;25:49–53
21. Kilic E, Ozaydin I, Atalan G, et al: Transposition of the sacrotuberous ligament for the treatment of coxofemoral luxation in dogs. *J Small Anim Pract* 2002;43:341–344
22. Ozaydin I, Kilic E, Baran V, et al: Reduction and stabilization of hip luxation by the transposition of the ligamentum sacrotuberale in dogs: an in vivo study. *Vet Surg* 2003;32:46–51
23. Cetinkaya MA, Olcay B: Modified knowles toggle pin technique with nylon monofilament suture material for treatment of two caudoventral hip luxation cases. *Vet Comp Orthop Traumatol* 2010;23:114–118
24. Pozzi A, Kowaleski MP, Dyce J, et al: Treatment of traumatic coxofemoral luxation by cemented total hip arthroplasty. *Vet Comp Orthop Tramatol* 2004;17:198–203
25. Haburjak JJ, Lenehan TM, Harari J, et al: Treatment of traumatic coxofemoral luxation with triple pelvic osteotomy in 19 dogs (1987–1999). *Vet Comp Orthop Tramatol* 2001;14:69–77
26. Venturini A, Pinna S, Tamburro R: Combined intra-extra-articular technique for stabilisation of coxofemoral luxation. Preliminary results in two dogs. *Vet Comp Orthop Traumatol* 2010;23:182–185
27. DeAngelis M, Prata R: Surgical repair of coxofemoral luxation in the dog. *J Am Anim Hosp Assoc* 1973;9:175–182

28. Bennett D, Duff SR: Transarticular pinning as a treatment for hip luxation in the dog and cat. *J Small Anim Pract* 1980;21:373–379
29. Hunt CA, Henry WB Jr: Transarticular pinning for repair of hip dislocation in the dog: a retrospective study of 40 cases. *J Am Vet Med Assoc* 1985;187:828–833
30. Beckham HP, Smith MM, Kern DA: Use of a modified toggle pin for repair of coxofemoral luxation in dogs with multiple orthopedic injuries: 14 cases (1986–1994). *J Am Vet Med Assoc* 1996;208:81–84
31. Kieves NR, Lotsikas PJ, Canapp SO: Hip toggle stabilization using the TightRope® system in 9 dogs. Proceedings of the 38th Annual Conference of the Veterinary Orthopedic Society, March 5-12, 2011, Snowmass, CO., p 64
32. Light VA, Steiss JE, Montgomery RD, et al: Temporal-spatial gait analysis by use of a portable walkway system in healthy Labrador Retrievers at a walk. *Am J Vet Res* 2010;71:997–1002
33. Kieves NR, Lotsikas PJ, Schulz KS, et al: Hip toggle stabilization using the TightRope system in 9 dogs. Proceedings of the 2011 American College of Veterinary Symposium; 2011 Nov 4–7. Chicago, Illinois. e33
34. Ash K, Rosselli D, Danielski A, et al: Correction of craniodorsal coxofemoral luxation in cats and small breed dogs using a modified Knowles technique with the braided polyblend TightRope™ systems. *Vet Comp Orthop Traumatol* 2011;25:54–60
35. Baltzer WI, Schulz KS, Stover SM, et al: Biomechanical analysis of suture anchors and suture materials used for toggle pin stabilization of hip joint luxation in dogs. *Am J Vet Res* 2001;62:721–728
36. Flynn MF, Edmiston DN, Roe SC, et al: Biomechanical evaluation of a toggle pin technique for management of coxofemoral luxation. *Vet Surg* 1994;23:311–321
37. Cook JL, Evan R, Conzemius MG, et al: Proposed definitions and criteria for reporting time frame, outcome, and complications for clinical orthopedic studies in veterinary medicine. *Vet Surg* 2010;39:905–908
38. Cook J, Luther J, Beetem J, et al: Clinical comparison of a novel extracapsular stabilization procedure and tibial plateau leveling osteotomy for treatment of cranial cruciate ligament deficiency in dogs. *Vet Surg* 2010;39:315–323
39. Burgess R, Elder S, McLaughlin R, et al: In vitro biomechanical evaluation and comparison of FiberWire, FiberTape, OrthoFiber, and nylon leader line for potential use during extraarticular stabilization of canine cruciate deficient stifles. *Vet Surg* 2010;39:208–215.
40. Rose ND, Goerke D, Evans RB, et al: Mechanical testing of orthopedic suture material used for extra-articular stabilization of canine cruciate ligament-deficient stifles. *Vet Surg* 2012;41: 266–272
41. Spranklin D, Elder S, Boyle C, et al: Comparison of a suture anchor and a toggle rod for use in toggle pin fixation of coxofemoral luxations. *J Am Anim Hosp Assoc* 2006;42: 121–126

