pISSN 1598-298X / eISSN 2384-0749
J Vet Clin 37(3) : 163-167 (2020)
https://doi.org/10.17555/jvc.2020.06.37.3.163

Journal of Veterinary Clinics
www.ksvc.or.kr

Treatment of Quadriceps Contracture with Femoral Shortening Ostectomy, Rectus Femoris Muscle Transposition and Dynamic Stifle Flexion Apparatus in a Dog

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(Received: April 06, 2020 / Accepted: May 26, 2020)

Abstract : A 13-month-old, 3.3 kg castrated male Shih-tzu presented with right hindlimb lameness. The physical examination revealed atrophy of the right thigh muscles, hyperextension of the stifle joint and external torsion of the tibia. On the radiographic examination, patella alta and genu recurvatum were observed. A biapical deformity of the tibia and external torsion of the distal tibia were detected by computed tomography (CT). A three-dimensional (3D) printed bone model was designed and constructed for the preoperative plan prior to surgery. Rectus femoris muscle transposition, femoral shortening ostectomy and open wedge osteotomy of the distal tibia were performed using hybrid external skele/t0al fixation (hybrid-ESF). A dynamic stifle flexion apparatus was used to prevent recurrence of a quadriceps contracture (QC). Intense physiotherapy was administered postoperatively. The dog began to use the affected limb one week after surgery. Functional improvement in the affected limb was observed, and full weight-bearing was possible at 3 months after surgery. Union of the osteotomy lines was observed at 3 months, and the stifle joint was fully movable at 7 months after surgery. Regarding the treatments for QC, these methods may be excellent candidates, as they do not lead to severe damage to the limb or amputation.

***Key words* :** dog, dynamic stifle flexion apparatus, quadriceps muscle contracture, Rectus femoris muscle transposition.

Introduction

Quadriceps contracture (QC), which is also known as post-traumatic stifle joint rigidity, quadriceps tie-down syndrome, stifle joint hyperextension, hindlimb rigidity, quadriceps ischemic contracture and Sudek atrophy, is a disease characterized by fibrous adhesion between the quadriceps muscles and the femur (1-3). QC is diagnosed infrequently in dogs. Most QCs are caused by postoperative complications with femur fractures in young growing dogs or congenital deformities (1-7). Severe lameness, hyperextension of the stifle and hock joints, atrophy and hardness of the femoral quadriceps muscle are the main characteristics observed in physical examinations (3,8). In the radiographic examinations, patella alta, medial patella luxation and coxofemoral subluxation or luxation are detected in most patients, and genu recurvatum is observed in extreme cases (3,8). The reported treatment options include conservative management or surgery. Although early detection and restoration of mobility through physiotherapy are considered the gold standard for the treatment of QC, surgical correction may be required in progressive cases. The prognosis of quadriceps contracture for complete recovery is "poor"; treatment may improve gait performance, but residual lameness usually remains (3).

Surgical options include release of the quadriceps muscle, lengthening Z-plasty of the quadriceps muscle or patella ligament, cuneiform osteotomy of the femur and release of the rectus femoris from the pubis (1-4,6-13). Lengthening Z-plasty can be performed to reduce tension or lengthen a restrictive muscle, but it may result in reunion of the muscles and recurrence of quadriceps contracture postoperatively (2,6,8). Femoral shortening osteotomy has been performed to minimize muscle damage (10). Rectus femoris transposition is the technique that reduces medially directed forces by transposing the origin of the rectus femoris muscle from the pelvis to the third trochanter of the femur (14). Postoperative transarticular external fixators or 90º-90º flexion splints have been used to maintain passive flexion of the stifle (8,15). A more recent review of outcomes has shown that surgical management with dynamic and static stifle flexion devices and physiotherapy can prevent recurrence of QC and improve range of motion (7,8,10,13).

This report describes the successful outcomes of surgical treatment involving femoral shortening ostectomy, rectus femoris transposition, and a dynamic stifle flexion apparatus in patients with quadriceps contracture. Short- and long-term clinical outcomes are reported.

Case

A 13-month-old, 3.3 kg castrated male Shih-tzu presented at Chungnam National University Veterinary Medicine Teaching Hospital with intermittent right hindlimb nonweight bearing lameness and hyperextension of the stifle joint. Hyperextension of the right stifle commenced after dystocia with posterior presentation at birth. The patient was fully vaccinated

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Table 1. Comparison of function of the right hind limb pre- and postoperatively (12). Thigh width is compared between the affected and contralateral limbs

	Pre-OP	Post-OP	Ref.
Extension (°)	220	204	153-162
Flexion (°)	170	80	33-42
ROM (°)	50	124	120-150
Thigh width (%)	74	84	100

and did not have a history of specific medical treatments.

In the physical examination, obvious hyperextension of the stifle joint with restricted flexion (Table 1), atrophy of the right thigh muscles and external rotation of the tibia were observed (Fig 1). No pain reaction was detected during palpation of the hindlimb. The radiographic examination revealed external rotation of the hindlimb in the neutral position, valgus deformity of the distal femur, subluxation of the coxofemoral joint, a biapical angular deformity, external torsion, a flattened tibial condyle and mild recurvatum of the tibia. In addition, patella alta and genu recurvatum were observed (Fig 2). Computed tomography (CT) was used to evaluate the deformities of the hindlimb. The anteversion angle of the femur was measured at 8° (reference range, 15° to 30°). The biapical deformity of the tibia and external torsion of the distal tibia were measured. Three-dimensional (3D) images were reconstructed using CT (Fig 2). A 3D printed bone model was designed for the preoperative plan.

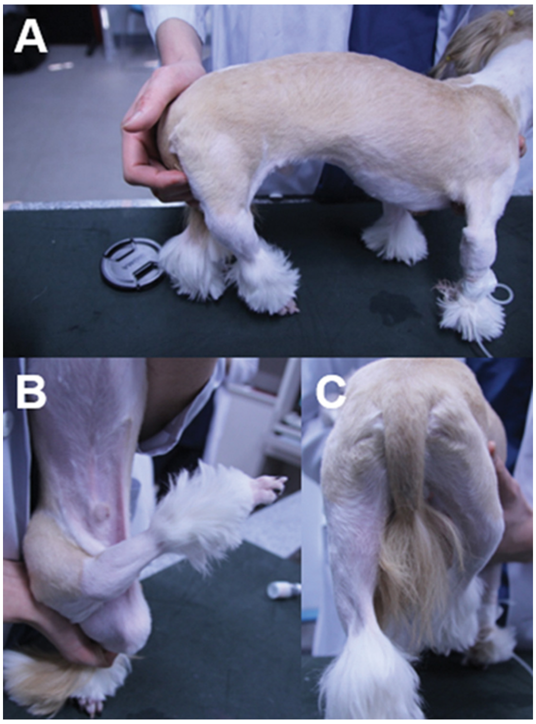

Fig 1. Preoperative standing view of quadriceps contracture on the right hindlimb (A). Note the significant hyperextension of the stifle joint (B) and external torsion of the tibia (C).

Surgery report

Instead of correcting bone deformity and atrophied muscle to their normal appearance, the aim of the surgery is to restore the function of the limb to walk and weight-bear as much as possible. Therefore, releasing the contracted muscle and rearranging the limb to allow maximum range of motion is the most critical step in this procedure.

General anesthesia was induced prior to surgery. The patient was premedicated with 0.1 mg/kg IV hydromorphone (Dilid inj. 1 mg; Hana Pharm) and 0.2 mg/kg IV midazolam (Midazolam Inj; Bukwang Pharmaceutical Co.). Anesthesia was induced with 4 mg/kg IV propofol (Anepol Inj.; Hana Pharm) and maintained with 2% isoflurane (Ifran; Hana Pharm) after intubation. For prophylaxis, 22 mg/kg IV cefazolin (Cefazolin Inj; Chong kun dang healthcare) was administered before surgery and thereafter at 90 minute intervals throughout surgery. A standard craniodorsal approach was performed in the hip joint. The rectus femoris muscle was transected near the muscle origin and transposed to the third trochanter of the femur. The incision was extended to the stifle joint along the craniolateral border of the shaft of the femur. A medial releas-

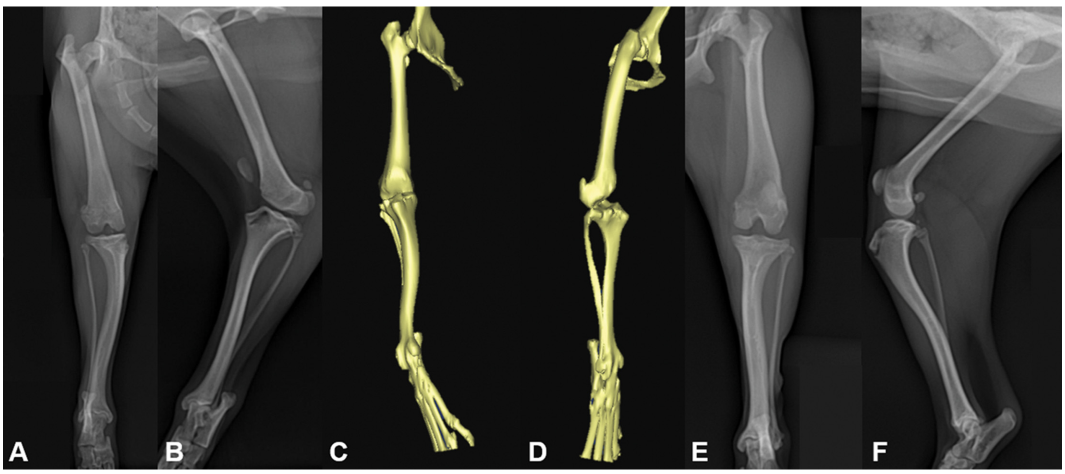

Fig 2. Craniocaudal and mediolateral radiographic views of the right (A and B, respectively) and left hind limbs (D and E, respectively). Craniocaudal and lateromedial CT reconstruction views of the right hind limb (C and D). Genu recurvatum, patella alta, severe muscle atrophy, hip subluxation and external torsion of the right hindlimb were observed (A, B, C and D).

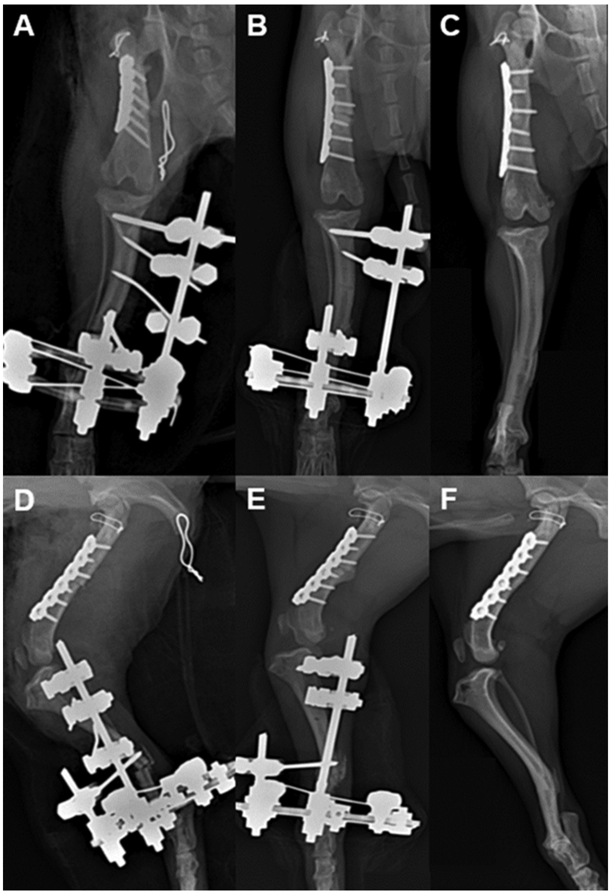

Fig 3. Immediate postoperative (A, D), 41 days postoperative (B, E) and 1056 days postoperative (C, E) craniocaudal (A, B, C) and mediolateral (D, E, F) radiographs of the right hindlimb. A wire was placed on the third trochanter of the femur to fix the origin of the rectus femoris and increase the stability of the bone-fixator component (A, D). 41 days after the operation, the dynamic stifle flexion apparatus was removed (B, E). A flexed stifle joint with sufficient surrounding soft tissue was noted without the fixator at 1056 days after the operation (C, F).

ing incision was made, and the adhesions of the muscle were isolated. The distance between the osteotomy lines for the shortening of the femur was determined intraoperatively visually. The patella was placed on the groove of the distal femur after releasing the medial patellar retinaculum. The patella moved 2 mm distally when the stifle joint was on 15 degrees of flexion. Therefore, 12 mm of bone segment on the femur, the estimated distance of the patellar bone position when the stifle joint was bent in 90 degrees more, was planned to be resected. The osteotomy lines were marked on the bone surface using a saw and scalpel. A threaded pin was placed craniocaudally on the femur, proximal and distal to the ostectomy region and parallel to the femoral sagittal axis. The ostectomy was performed using a pneumatic oscillating saw. The plate that was precontoured on the 3D printed bone model before surgery was applied to the lateral aspect of the femur, with the plate positioned to permit a minimum of three screws (six cortices) in each segment. The cranial crucial ligament remained intact in the stifle joint arthrotomy. The trochlear block recession technique was performed to

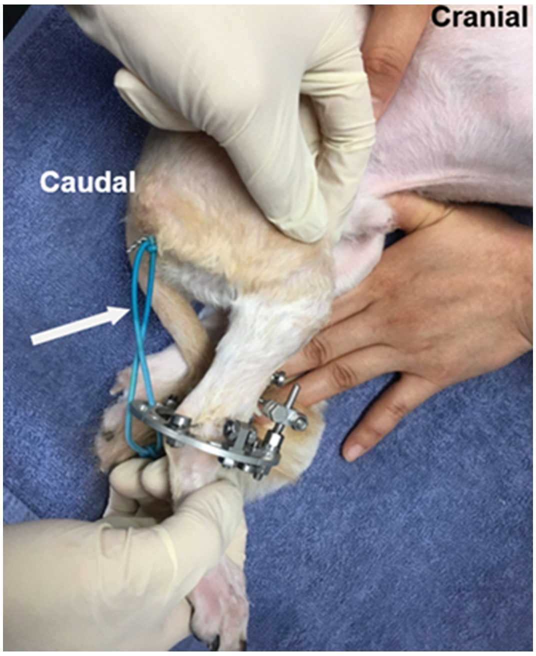

Fig 4. Application of dynamic stifle flexion apparatus (arrow) by connecting the circular ring of the ESF device and the wire loop on the ischium with rubber elastic band.

achieve an adequate trochlear depth for patella tracking and resistance to luxation. A small skin incision was made at the medial part of the tibia. Open wedge osteotomy was performed to correct the external torsion and to restore flexion-extension function of the limb with weight bearing. A full ring of the circular external skeletal fixator was placed in the distal part of the tibia and fixed with two wires across the bone. Mediolateral pins, rods and clamps were applied for hybrid external skeletal fixation (hybrid-ESF) on the tibia (Fig 3). After the femur and tibia surgery was completed, a dynamic flexion apparatus was installed (Fig 4). A hole on the ischiatic tuberosity was made using a drill and the caudolateral approach. The flexible pelvic wire was passed through the hole, and a loop was made. The wire loop on the ischium and the circular ring of the ESF were connected by a rubber elastic band (Maru rubber, Hangyang TNC), which was tied to each segment. The subcutaneous tissue and skin were closed in a routine manner. The postoperative radiographs taken every 3 weeks confirmed appropriate implant placement and alignment of the hindlimb.

Perioperative and postoperative management

Staged disassembly of the hybrid ESF began 6 weeks after surgery under mild sedation, and the device used for hybrid ESF was completely removed at 2 months after surgery (Fig 3). Physiotherapy was performed to stretch the quadriceps muscle and promote the use of the limbs. Extension of the stifle joint was restricted by the apparatus. The rubber was replaced with 10% longer pieces of rubber each week to reduce the restriction on the stifle joint flexion and increase the range of motion. The apparatus was removed 4 weeks after surgery. Heat therapy, passive range of motion (ROM), toe touching, leash walking, and hydrotherapy (after ESF device removal) were performed postoperatively. Gradual improvement in walking was observed, and partial weight-bearing walking was possible 7 days after surgery. Full weight-bearing was possible at 3 months after surgery. At 7 months, the thigh girth measurement improved from 74% to 84% on the affected limb compared to the contralateral limb (Table 1), and the ROM of the stifle joint improved (80° in flexion and 204° in extension). Although ROM was not restored to the normal range (reference ranges, 42 ± 2° and 162 ± 3°, respectively) (12), gait performance improved consistently, and QC resolved postoperatively. Although hyperextension of the stifle joint remained during walking, the owner was satisfied with the clinical results.

Discussion

Quadriceps contractures not related to fracture complications are rare. Several management strategies and treatments have been reported to unsuccessfully restore the function of the hindlimbs in patients with QC (3). Although the treatment options depend on the severity of the disease, salvage techniques such as arthrodesis or amputation are indicated for the nonfunctional limb (10,11). For the case presented here, rectus femoris muscle transposition and femoral shortening ostectomy were performed. These techniques have the advantages of yielding minimal damage to muscles and restoring stifle joint flexion. The quadriceps contracture was successfully managed. The stifle joint range of motion was restored by using a dynamic stifle flexion apparatus and intense physiotherapy after surgery, as reported previously. Although previous studies have reported that the prognosis of QC for complete recovery is poor, restoration of the function of the affected limb by 50 to 75% is considered a successful surgical result according to a previous report (4). The owner reported improvement in gait performance and posture.

Possible etiologies for quadriceps contracture include trauma, postoperative complications of femoral fracture, and prolonged stifle extension due to poor management and infection at a young age. A definitive etiology could not be confirmed in this case because there was no history of surgery or infection. The CT findings suggest concomitant deformities in the tibia and femur (Fig 2). While QC may have been secondary to previous trauma at birth, congenital deformities cannot be excluded in this case (1,4,6,7).

Lengthening Z-plasty of the quadriceps muscle has been reported to treat QC in previous reports, but this technique can damage muscle tissue, leading to excessive fibrous change and recurrence of QC during the healing process because damaged muscles can heal by the replacement of the injured tissue with fibrous tissues (2,6,8,11,16). In addition, it has been reported that muscle contracture is usually accompanied by shortening and hypofunction of the affected muscle (11). Therefore, rectus femoris muscle transposition and femoral shortening were performed to treat this patient. The rectus femoris muscle, which is part of the quadriceps mechanism, originates from the shaft of the ilium. The rectus femoris muscle helps extend the stifle and flex the hip joint (14). Flexion of the hip joint by contracture of the rectus femoris leads to an increased medially directed force and contributes to luxation or subluxation of the patella (14). Transposition of the origin of the recuts was performed to correct the hyperflexed hip joint and hyperextended stifle (14). This technique has been used to correct medial patella luxation and resulted in the realignment of the quadriceps muscle and reduced medially directed forces (14).

In addition to the transposition of the rectus femoris, stabilization of the quadriceps muscle and other procedures, such as femoral shortening and muscle release, yielded satisfactory results. Femoral ostectomy can successfully correct issues caused by shortened muscles, resulting in reduced muscle strain and minimal damage to muscles. In this case, 11% of the total length of the femur was shortened by ostectomy to reduce the tension in the quadriceps. There is no standard guideline for femoral ostectomy length in a dog. In a previous report, normal gait was maintained when the femoral length was reduced by as much as 20% (17). The aim of surgery is to restore the function of the limb by releasing the contracted limb rather than reconstructing the anatomic shape of the bone, thus promoting weight bearing of the patient.

Hybrid ESF was used to correct the deformities of the tibia after open wedge osteotomy. There was a biapical angular deformity, external torsion, a flattened tibial condyle and mild recurvatum of the tibia. It is not easy to correct these bone deformities simultaneously (12). The hybrid-ESF method was considered because the patient was a small-breed dog and the bone deformities were located near the joint (12). Additionally, the hybrid ESF allow to correct the limb alignment postoperatively based on the walking stance. The Hybrid ESF could be connected to wire loop on the ischium with a rubber elastic band to prevent hyperextension of the stifle joint. After surgery, bone fusion was successful in the osteotomy line, and no major complications, such as bone infection, were observed. Although it can interfere with postoperative walking or prolong the healing process, hybrid ESF has been successfully applied, yielding rapid recovery of walking function and healing while ensuring postoperative stability. The dynamic stifle flexion devices were applied postoperatively to restrict the range of extension of the stifle joint as well as stretch and lengthen the quadriceps muscles. In addition, they restricted the range of motion. Static stretching of the muscle increases the joint range of motion by decreasing the viscosity and increasing the elasticity of muscle-tendon units (18). Intense physiotherapy was performed postoperatively. The goal was to improve the range of motion of the stifle joint, decrease the fibrotic change in the muscles.

The limitations of our technique mainly include the complicated and broad surgical site and prolonged surgical time. Therefore, the technique described in this paper cannot be recommended as a first line of treatment but should be reserved for cases in which function of the limb can be partially restored. Additional research needs to be conducted to establish more detailed guidelines for quadriceps contracture treatment.

Conclusion

This report demonstrates that femoral shortening osteotomy and rectus femoris transposition are suitable treatment options for QC in dogs. Additionally, using a dynamic flexion apparatus with intense physiotherapy may prevent the recurrence of QC and promote the gradual lengthening and stretching of the quadriceps muscles. The clinical outcomes of this patient who underwent this technique were excellent, and the patient was able to return to weight-bearing activities. This method may be useful in treating quadriceps contracture in dogs. However, this technique should only be selected after a thorough evaluation of the other available treatments.

Acknowledgements

This study was supported by research fund of Chungnam National University.

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