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Application of a triangular saw guide in cranial tibial wedge osteotomy in ten cats

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Summary

A traumatic etiology of mechanical injury, trophic and degenerative changes are common etiopathogenesis of cranial cruciate ligament injury in cats. The aim of the study was to assess the usage of the authors own design triangular saw guide for surgery of the cranial tibial wedge osteotomy in feline patients. Cranial tibial wedge osteotomy procedures were performed in 10 cats of both genders. The appliance of a triangular saw guide and modified technique ensures meticulous orthogonal incision in the course of the cranial tibial wedge osteotomy and enables achieving a levelling of the tibial plateau precisely, reducing cortical damage and significantly decreasing the surgical time. It provides an adequate environment for bone union within three months post operatively.

Keywords: ruptured, cruciate ligament, tibia, plateau, orthogonal

The rupture of the cranial cruciate ligament (RCCL) is generally associated with trauma, but degenerative processes of the cranial cruciate ligament (CCL) have previously been described in feline patients (6, 20, 21). Treatment of RCCL aims to resolve lameness and persistent signs of osteoarthrosis. The conservative treatment approach to RCCL may be successful, although it has been suggested by numerous authors that early surgical intervention may limit the development of osteoarthritis, promote recovery and accelerate the recurrence of joint function (2, 6, 28). Following the study by Henderson and Milton (9) describing the fundamentals and significance of the cranial tibial thrust (CTT) a paradigm shift in the techniques used to treat CCL rupture towards changing the stifle joint biomechanics and disabling function of the cranial cruciate ligament is presented. The original periarticular osteotomy technique described by Slocum (25) which is known as the cranial tibial wedge osteotomy (CTWO) used in RCCL cases has also been used in feline patients (10, 17). Establishing the tibial plateau angle (TPA) and the angle of osteotomy are crucial in planning the precise CTWO procedure. The main objectives of osteotomy are to obtain a TPA value which allows for a reduction in CTT (11, 25). Some studies suggest using various types of callipers and a cutting guide to facilitate this procedure, ranging from simple sets of triangular strips with various triangulations, to complex guide systems (13, 15, 24). The aim of the study was to assess the utility of the triangular saw guide (TSG) in CTWO for the treatment of RCCL in feline patients with the aim of a satisfactory return to functioning.

Material and methods

Owner consent for data collection, publication and research was obtained for each cat before enrolment into the study. Presumptive diagnosis of RCCL was based on orthopaedic examination. Cranial drawer and tibial compression tests were both evaluated and found to be positive in all patients (7). Each feline patient was evaluated prior to surgery including complete blood count and blood biochemistry, no major abnormalities had been observed. The genders included two entire males, two entire females, two neutered females and four neutered males. Mean BCS was 6.0 (± 0.9). Detailed data is presented in Table 1.

Also, stifle joints lateral radiographs were performed in accordance with Morris and Lipowitz (18), under general anaesthesia prior to surgery. During radiographic evaluation, TPA was measured using digital radiography (DR) with the use of OsiriX™ (Pixmeo SARL, Bernex, Switzerland) digital software at 50% magnification (4, 18). Each TPA measurement was performed by experienced staff members: a certified veterinary surgeon and a certified radiologist. Radiographs of the stifle joints were obtained

Tab. 1. The clinical characteristics of cats with cranial cruciate ligament injury, treated with CTWO

Case No.	Breed	Side affected limb	Gender	Age (mo)	Body weight (kg)	BSC	Pre-operation TPA (°)	Post-operation TPA (°)	Time between the first clinical sign occurrence and the surgery (days) signs to operation (days)	Surgery time (min)	H-M scale 0/1/2/3 (mo)	C-B scale 0/1/2/3 (mo)	Complications
1	Domestic Shorthaired	L	nm	68	5.2	6	25	5.0	15	30	4/2/1/1	4/4/3/3	WH
2	Domestic Shorthaired	R	nf	74	4.6	5	26	5.5	21	29	4/1/0/0	4/3/2/2	–
3	Domestic Shorthaired	L	nm	62	5.8	7	26	6.6	22	27	3/2/1/0	4/4/2/1	–
4	Domestic Shorthaired	L	nf	60	7.5	7	28	6.0	10	37	3/2/0/0	4/4/2/2	SSI/CPAT
5	Domestic Shorthaired	R	nm	56	4.8	6	27	6.0	75	35	4/1/1/0	4/3/2/2	–
6	Domestic Shorthaired	L	f	77	3.8	5	28	5.5	25	35	4/3/2/0	4/3/2/2	SSI/CPAT
7	Maine Coon	R	m	54	7.2	7	25	5.0	30	32	3/1/0/0	4/3/3/2	SSI/CPAT
8	British Shorthair	L	m	58	6.2	6	28	7.0	28	34	4/2/1/0	4/3/2/1	–
9	British Shorthair	L	nm	64	4.5	5	27	7.6	18	26	4/2/1/0	4/3/2/1	–
10	Persian	L	f	48	3.2	5	27	6.2	3	30	3/1/1/0	4/3/2/1	WH
median	–	–	–	62.5	5.35	6	26.5	6.0	39	31.5	–	–	–
SD: ±	–	–	–	8.97	1.4	0.9	1.16	0.84	19.48	3.69	–	–	–

Explanations: m – male; f – female; nm – neutered male; nf – neutered female; R – right; L – left; SSI – surgical site infection; CPAT – concurrent postoperative antibiotic therapy; WH – weakened consolidation; BSC – Body Condition Score; TPA – tibial plateau angle; H-M scale – Hazewinkel-Meutstege scale; C-B scale – Corr-Brown bone union scale

to exclude neoplastic processes within the femur or tibia. Any radiographic signs of osteoarthritis were graded on a five point scale; normal = 0, trivial = 1, mild = 2, moderate = 3, and severe = 4 (5). Feline patients with a score of 0 to 2 qualified for CTWO surgical treatment. The aim of the radiological measurements was to determine the angle of osteotomy (β angle) and to achieve a 5° postoperative TPA. In dogs, a postoperative 5° TPA value neutralizes the cranial tibial thrust (26). No such relationship has been described in cats, although some observations prove this possibility (21).

For the surgery technique and structure of the TSG, a medial arthrotomy was conducted on all enrolled feline patients to confirm diagnosis of RCCL. The CTWO surgery was based on a technique described by Slocum and Devine (25). The osteotomy was located at the crista tibiae (10). In each case, the β angle equalled the angle of the triangular saw guide used. The osteotomy was performed using an oscillating saw blade with a straight 7.5 mm edge with a modification based on the usage of a custom designed TSG (Fig. 1).

The TSG was made from surgical steel with a 4 mm thickness. The thickness and shape of the guide were chosen empirically (for precision in guiding the oscillating blade and their resistance to deformations). The optimal length of the edges was set at a, b, c = 30 mm. At the same time, the number, position and diameter of the operating fenestrations (ϕ = 1.15 mm) (Fig. 1) for fixing threaded Kirschner pin wires (ϕ = 1.00 mm) to the facies medialis tibiae were defined. Finally, 16 guide plates were designed and created with osteotomy angles variated from 15° to 30°. A saw guide was fixed in position so that the guide fissure was directed (marked x) perpendicular to the long axis of the tibia. Subsequently, the TSG was fixed to the tibial shaft using 2 threaded Kirschner pins (ϕ 1.0 mm) (Fig. 2).

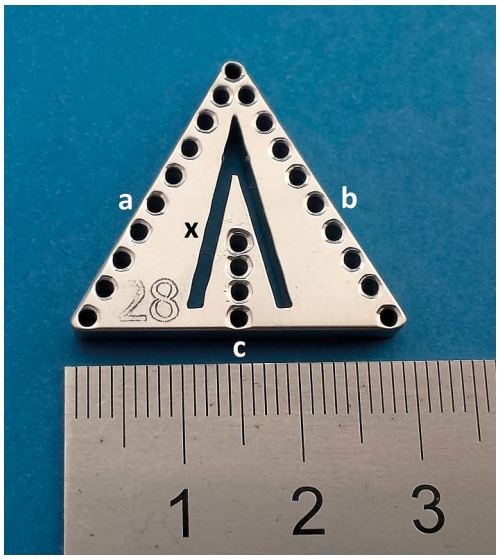

Fig. 1. The triangular saw guide (element 28°)

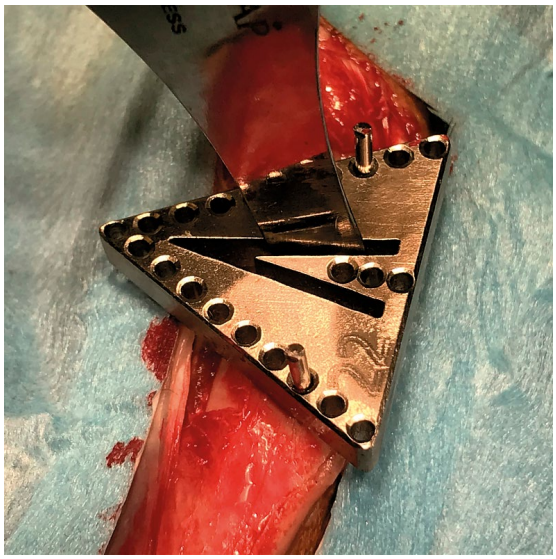

Fig. 2. The triangular saw guide during the osteotomy (fixing using threaded Kirschner pins)

Fig. 3. Domestic Shorthair Cat, F, 77 months, hind left limb, Cr-Cd and M-L views, 1,6 mAs, 47 kV

Fig. 4. Domestic Shorthair Cat, F, 77 months, hind left limb, Cr-Cd and M-L views, 1,6 mAs, 47 kV

The osteotomy was closed using a 2.7 mm tibial plateau levelling osteotomy plate (Medgal-VET, Białystok, Poland) and six locking self-tapping screws of 2.7 mm (Medgal-VET, Białystok, Poland). The orthogonality and the quality of osteosynthesis were checked with an intraoperative radiograph (Fig. 3, Fig. 4).

The soft tissues: the fascia, subcutaneous layer and skin were closed routinely. As a part of their aftercare at home, all cats were provided with an Elizabethan collar and the owners were advised to cage rest them for the following 4 weeks.

In order to evaluate osteotomy, implant positioning and achieve TPA, radiographs were obtained immediately postoperatively. The first follow-up radiographic evaluation was performed one month after surgery and the procedure was repeated every four weeks until 3 months after surgery. Throughout the follow-up radiographs, the cats were positioned in lateral recumbency without any sedation. Bone union was assessed with a mediolateral projection. Osteotomy healing was graded according to the Corr-Brown bone union scale (C-B scale); 1 – very good, 2 – good, 3 – satisfactory, 4 – poor, 5 – no consolidation (3). The degree of lameness was assessed using a Hazewinkel-Meutstege scale (H-M scale), and scored as follows: 0 (no lameness), 1 (barely disturbed mobility), 2 (mobility disturbed but limb(s) still bearing weight), 3 (lameness with limb(s) not always bearing weight), 4 (no weight bearing on limb(s)) (8, 12). The breed, age, weight, gender, TPA value (pre-operation and post-operation), time elapsed from the development of the clinical signs to the time of the operation, surgery and anaesthesia time, assessed lameness and consolidation for each cat with CCLR were recorded. The body condition score for each cat was also evaluated according to a 9-point system Body Condition Score (BSC) (14).

A descriptive analysis of the results and graphic illustrations were created by using Statistica v.10.1 software (Statsoft Inc., now TIBCO Software Inc., Tulsa, OK, USA). All of the relevant values are presented in terms of a numerical value and standard deviation (SD). The statistical significance was set at $P < 0.05$. The selected indicator of result correlations were calculated at $P < 0.05$. The bone union progress (C-B scale) and the correlation between bone union and the degree of lameness (H-M scale) were also analysed. The Guilford scale was used to assess the correlation strength between parameters. A written consent form was obtained from the cats owners enrolled in the study.

Results and discussion

Ten cats of both genders involved in this study were treated using the CTWO surgery of the stifle joint for unilateral RCCL. All of them were outdoor cats. The represented breeds included; six Domestic Shorthair cats, one Maine Coon, two British Shorthair and one Persian cat.

The results of the performed laboratory tests, including the complete blood count, alanine transaminase, aspartate transaminase, urea and creatinine assessment were within the reference range limits (19). Orthopaedic examination showed that seven left and three right limbs were affected. In all of the presented cases joint pain was marked and stifle joint effusion was present. All of the patients tested positive for both the tibial compression test and cranial drawer test. None of the cats enrolled in the study had any previous surgical history of the affected joint. Intraoperative findings using the medial arthrotomy technique revealed a complete rapture of the cranial cruciate ligament with no evidence of caudal cruciate ligament pathology. Furthermore, there were no meniscus abnormalities in all presented cases. Cranial tibial wedge osteotomy was performed without major technical difficulties and only minor postoperative complications were recorded (Tab. 1). Radiograph evaluation recorded the preoperative value of TPA to be a median 26.5° (SD: ± 1.16), while the postoperatively achieved value of TPA was: median 7° (SD: ± 1.17) (Tab. 1). The treatment outcome including lameness evaluation and the progression of the treatment (H-M scale) are presented in Figure 5.

The coefficient correlation of lameness alterations (H-M scale) and osteotomy consolidation/bone union (C-B scale) with $r = 0.998$ during treatment (Fig. 6).

There were no major complications in the postoperative period, although two cats were affected with a prolonged drainage from the surgical wound (> 2 weeks). The average documented surgical time for all

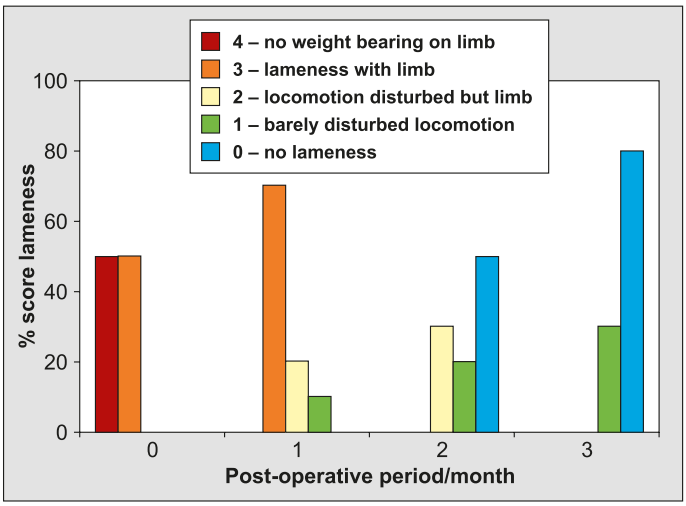

Fig. 5. Assessment of the degree of lameness during the treatment

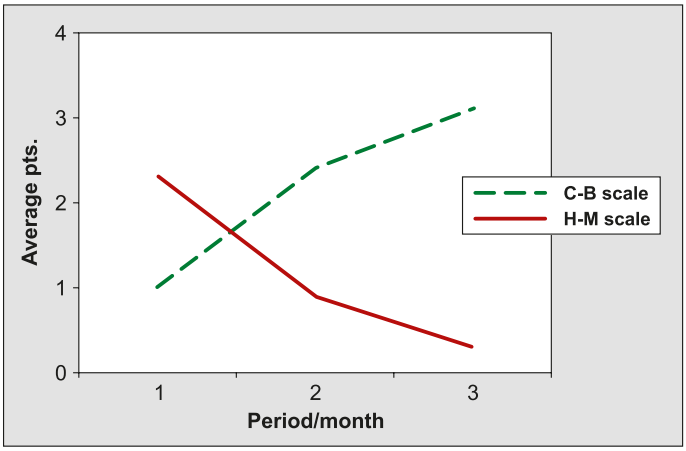

Fig. 6. Calculated changes in point values on the C-B scale versus the H-M scale in the post-surgical period; C-B scale – Corr and Brown bone union scale; H-M scale – Hazewinkel and Meutstege degree of lameness scale

cases was 31.5 min. (SD: ± 3.69). Data concerning the time interval between the occurrence of the first clinical sign and the beginning of the therapy period was collected and found to be 39 days on average (SD: ± 19.48). Detailed data is presented in the Table 1.

Numerous advantages were identified with the appliance of TSG and the technique described above. The use of TSG and our own technique allowed us to assign a calculated angle of osteotomy values effortlessly and precisely to the operating area. Mindner et al. (17) reported that the use of a saw guide increases surgical trauma and the duration of the surgery. Our observations showed that the presented modification definitely decreases surgical time with the median time of surgery being 31.5 min. (SD: ± 3.69) in the performed studies. The lack of a securely stabilized saw guide may lead to inaccuracy throughout the osteotomy procedure and intraoperative complications, such as fracture/damage of the stabilizing system and/or rotation of the proximal part of the tibia, impairment of the periosteum and cortical bone which are often observed (13, 15). However, the complications raised above do not occur with the assistance of TSG. We did not record any remodelling in the tibial axis and oblique orientation of the osteotomy postoperatively. It should be noted that the construction of TSG is undemanding, the guide is fixed during the osteotomy, and the technique of its application is facile. The application of TSG allowed for the achievement of the orthogonal osteotomy planes. Furthermore, osteotomy with the use of TSG minimized the degree of iatrogenic periosteum and medial cortical bone damage, this was described previously in the studies of Burton et al. (1).

The value of achieving orthogonal planes and their possible impact on bone union has been described by this author (1). An impeccable orthogonal plane is crucial for the prevention of postoperative limb malalignment (22). During our research, callus formation and lameness resolution times were monitored after osteotomy. In the second month after surgery the radiological assessment of bone union (C-B scale) revealed that 60% of the cats had grade 2 osteotomy healing. Consolidation levels of grade 2, 3 and 4 were achieved by 40%, 10% and 50% of patients respectively in the third month post-operatively. The radiological abnormalities had improved during the study and the periodic changes were statistically significant. An assessment according to the H-M scale revealed that 50% of the cats were affected with grade 4 and the remaining 50% with grade 3 lameness prior to surgery. During the study, improvement was noted and no lameness was observed during the following up consultation 3 months after surgery. However, a thorough examination revealed a mild lameness of grade 1 on the H-M scale in 30% of the cats enrolled in the study. The assessed values of lameness decreased significantly throughout the observation period. The Pearson's correlation coefficient was assessed in the 1st month postoperatively and only reached a low level. In comparison, the correlation between results in the second and third months post-operatively achieved a moderate level and was statistically significant ($r = 0.40$, $r = 0.52$, respectively). In the course of the study, the coefficient correlation was determined to be $r = 0.998$ for the degree of lameness (H-M scale) versus bone union (scale C-B). Interpretation in accordance to Guilford's scale indicates a close negative reliable relationship between the previously listed variables over a period of time. A significantly inversely proportional relationship was demonstrated. This shows that the reduction in lameness was dependent on the elevation of the degree of osteotomy consolidation. This was noted during the study.

The CTWO method produces a high mechanical strength and may be successfully used in cats regardless of their body weight. The presented results are consistent with previous studies (3, 24, 27). It was indicated that a high TPA may predispose cats to CCL rupture (21). The median of pre-operative TPA was 26.5° (SD: ± 1.16) in the presented study. For the enrolled patients, a postoperative TPA of 5° (which

is recommended in dogs) was not achieved (median 7°, SD: ± 1.17); however, this was not crucial within the short-term follow up consultations and needs to be evaluated in the future. There is a probability that the postoperatively recorded TPA value is sufficient to neutralize cranial tibial thrust and stifle stabilization, although no such relationship has been described in cats to date. Witte and Scott (29) described the hypothesis by which the neutralization of cranial thrust after surgery may also allow for other mechanisms, such as neuromuscular proprioceptive feedback and strength in the stifle flexor muscles, in order to fully stabilize the stifle, this should also be considered. For all of the cats in the study, CTWO was performed without major technical difficulties and with minor postoperative complications, which means no further surgery would be necessary to manage the condition. Minor complications noted above occurred in five of the enrolled cats and consisted of a superficial wound infection and prolonged drainage and were associated with over-grooming, insufficient resting and inaccurate aftercare at home. The superficial wound infection was treated with a single subcutaneous injection of a dose of 8 mg/kg of Convenia (Cefovecin, Pfizer, Sandwich, UK) in each case. Twelve weeks after the operation, a return to complete functioning, mobility and welfare was achieved in all cats. The clinical outcome was considered faultless and comparable to other studies (10, 16, 23). No evidence of recent trauma was revealed by clinical examination and no accidents were reported. Taking into consideration that the overweight cats had an average BCS of 6 (± 0.9), it may be assumed that the degenerative disease was a probable cause of the CCL injury, although the final aetiology was not determined.

Based on observations, the modification of the CTWO technique with the appliance of TSG in feline patients simplifies the radiologically obtained osteotomy angle repositioning in the surgical field and ensures precise orthogonal osteotomy incisions throughout the CTWO operation. The use of TSG and a modified technique also allowed for the achievement of a precise levelling of the tibial plateau, thereby decreasing the surgical time, preventing iatrogenic periosteum and medial cortical bone damage. Furthermore, the time required for the return of full limb functioning is decreased by providing an adequate environment for osteotomy consolidation within three months. The preliminary results from this study support the application of this technique to feline patients; nevertheless, an extended quantity of enrolled cases is necessary to evaluate the long-term outcome.

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