TIBIAL TUBEROSITY ADVANCEMENT (TTA) AS A POSSIBLE SOLUTION TO THE CRANIAL CRUCIATE LIGAMENT RUPTURE IN THE DOG

L'AVANZAMENTO DELLA TUBEROSITÀ TIBIALE (TTA) COME POSSIBILE SOLUZIONE ALLA ROTTURA DEL LEGAMENTO CROCIATO ANTERIORE NEL CANE

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SUMMARY

Cranial cruciate ligament (CCL) rupture represents one of the main causes of lameness in the dog. All the surgical techniques in use shows, under different points of view, problems or contraindications. Recently, a different view of the stifle biomechanics lead to the development of techniques, like TPLO®, that reach the joint stabilization through the variation of the tibial plateau slope, rendering unuseful the CCL reconstruction. Under this point of view, the Zurich Surgical Vet School has pointed up the Tibial Tuberosity Advancement (TTA) that, using and expanding the TPLO® biomechanical concepts, reach the same goal through a different way.

33 subjects with CCL rupture underwent TTA surgery. TTA neutralize all the forces acting on the tibial plateau with an anterior translation of the tibial insertion of the patellar ligament obtained with a tibial tuberosity osteotomy. The tuberosity fragment is then fixed in the new position with a special plate, and maintained at the right distance with a titanium cage.

The short term follow-up shows the restoration of a good motor function and an apparent stop of the osteoarthritis (OA) progression. The advantages of this technique resides in its simplicity. Limitations seem to be represented by the difficulty to correct, in the mean time and without further surgeries, limb deformities or excessive tibial slope. It is still not clear if, like in TPLO®, meniscal release is necessary. Long term results, both under clinical, radiographical and functional point of view, with help of force plate analysis, have to be evaluated.

Key words: dog; cranial cruciate ligament; tibial tuberosity advancement.

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RIASSUNTO

La rottura del legamento crociato anteriore rappresenta una delle più frequenti cause di zoppia del cane. Le tecniche chirurgiche proposte a tutt'oggi presentano, in misura diversa, lacune e limitazioni d'impiego. Una concezione diversa della biomeccanica del ginocchio ha portato di recente allo sviluppo di tecniche diverse, quali la TPLO®, che attraverso la modificazione dei piani articolari del ginocchio, tendono a rendere inutile la ricostruzione del legamento crociato anteriore (LCA) neutralizzando le forze che su di esso normalmente agiscono. In quest'ottica la Scuola Veterinaria di Zurigo ha proposto la tecnica di avanzamento della tuberosità tibiale (TTA) che, sfruttando ed ampliando i concetti biomeccanici della TPLO®, giunge ad un risultato analogo seguendo un approccio chirurgico differente.

Sono stati sottoposti ad intervento chirurgico per la stabilizzazione di ginocchia affette da rottura del LCA 33 soggetti, utilizzando la TTA. La tecnica raggiunge l'obiettivo di neutralizzare le forze agenti sul piano articolare tibiale, spostando anteriormente l'inserzione del legamento tibio-rotuleo attraverso un'osteotomia della tuberosità tibiale, che viene fissata con un'apposita placca e mantenuta in posizione con un cestello distanziatore in titanio.

I follow up a breve termine mostrano una buona ripresa della funzione motoria ed un apparente arresto della progressione dell'osteoartrite (OA). I vantaggi sembrano essere rappresentati dalla facilità di applicazione della tecnica. Le limitazioni risiedono nella difficoltà nel correggere contemporaneamente, e senza ulteriori interventi, alterazioni dell'allineamento dell'arto o angolazioni del plateau tibiale eccessive. Non è ancora chiaro se anche nella TTA, come nella TPLO®, sia necessario ricorrere al meniscal release. Restano da verificare i risultati a lungo termine, sia dal punto di vista clinico, che radiografico, che funzionale, con l'ausilio della force plate analysis.

Parole chiave: cane; legamento crociato anteriore; avanzamento della tuberosità tibiale.

INTRODUCTION

Cranial cruciate ligament (CCL) rupture is arguably the most common cause of lameness in dogs. Since 1952, when Paatsama first described this disease characterizing the surgical management (Paatsama, 1952), year by year numerous surgical techniques, each with its own advantages and troubles and each one, time by time, presented as effective solution for the joint instability subsequent to the CCL rupture. The high number of surgical techniques presented induced Olmstead to say that a surgeon cannot consider himself an orthopaedic one if he has never presented his own particular way to treat the CCL rupture, demonstrate the diffuse poor satisfaction for the obtainable results. In few words, all techniques "work", but no one "satisfy" seems to be the common result.

The relative complexity of the intracapsular techniques has recently led most orthopaedic surgeons towards the less invasive and more simply intracapsular techniques, where the modified medial retinacular embrication (Flo, 1975) seems to be the most used one. This is apparently working in all subjects, regardless of size and age, associated with less complications and less osteoarthritis (OA) development (Conzemius et al., 2005).

In the last ten years a new technique abruptly entered in the list of possibilities. This new technique looks at the stifle in a different way, more focused on a new biomechanical concept of the joint than the previous ones, considering the stifle stability as a complex of intra and extrarticular factors, involving joint anatomy, muscular function and weight, strictly working together. The goal then is not more to substitute the CCL or to restore its function, but to neutralize this function, shifting the forces acting on the tibial plateau towards the Caudal Cruciate Ligament (CaCL). This technique, called Tibial Plateau Levelling Osteotomy (TPLO®), in the face of good surgical results, is considered complex and invasive, requiring dedicated instrumentation with International Patent and thus reserved to trained surgeons (Slocum, 1987; Slocum & Slocum, 1993).

Because of these motives and since some Authors consider TPLO not more effective than other techniques (Aragon & Budsberg, 2005, Conzemius et al., 2005), new techniques were developed, always following a biomechanical approach.

The Slocum idea was that most of the motives for rupture and fail to repair of CCL reside in the rear limb anatomical conformation, particularly represented by the excessive tibial plateau slope in respect with mechanical axis of the tibia. The tibial slope finally increase, during stance and moreover during motion, the cranial tibial trust (CTT), described first by Henderson and Milton (1978), not adequately antagonized by pes anserinus muscle group. Modifying the tibial slope to obtain an angle of 6-8 degree with respect of the tibial mechanical axis could neutralize the CTT and translate on the CaCL the role of stabilizer of the stifle joint during the weight bearing and propulsive phase of motion.

Recently the Zurich Vet School expanded this concept, looking at the stifle as an articulated system where anatomical configuration, weight, muscle strength, and relative joint position interact each other. Slocum's concept of the stifle then become too simplistic, because in the stifle biomechanics have to be considered non only the pes anserinus muscle group, but at least also the quadriceps mechanism and the action exerted by the gastrocnemius tensile strength, in a word all the antigravitational muscles. Their biomechanical considerations lead to the observation that the CCL stabilizing action is working every time the tibial plateau form with the patellar tendon an angle greater than 90 degree. With smaller values of this angle the stabilizing action were performed by the CaCL, with the cross-over (balance between CCL and CaCL stabilizing action) exactly at 90 degree. Consequently, anterior advancement of the patellar tendon to reach a 90 degree angle in full leg extension, can shift the weight bearing and stabilizing action on tibial plateau and CaCL.

This could lead to results similar to TPLO, with a greater attention to the global muscular function and with a simplified and less invasive surgical approach (Montavon et al., 2004).

MATHERIALS AND METHODS

In the period October 2004-October 2005, among the subjects referred to the Dept of Vet Clinical Sciences of the University of Pisa and the Apuana Vet Clinic for CCL rupture (partial or complete), whose owners consciously choose for a "Osteotomy type" (TPLO, TTA) surgical correction, were randomly selected 33 dogs that underwent TTA surgery. Three subject underwent bilaterally surgery, with a final number of 36 stifle joints treated with TTA (12 right, 24 left). All the subjects were of different breeds and weight, aging from 1 and 13 years, divided into 20 males and 13 females (Tab. I).

A complete clinical examination was preoperatively performed to exclude concomitant pathologies that could negatively influence the outcome of the surgery. Then, under general anaesthesia, a complete radiographic examination of the rear limbs were undertaken, both in caudocranial view and in lateral 135 degree extended view, to evaluate the correct limb aligment, to measure the amount of tibial tuberosity advancement and to choose the size of implants. For this purpose a special transparent mask is available with instrumentation.

The mask presents the plate contour and a advancement guide. This guide is apposed with the horizontal axis lying on the tibial plateau axis, and with the vertical axis corresponding to the patellar insertion of the patellar ligament. The distance between the vertical line and the tibial tuberosity represent the amount of advancement request, and is simplified in three measures: 6, 9 and 12 mm, corresponding to the measure of dedicated cages. The plate I chosen taking care the length of its anterior part be exactly the same of the tibial tuberosity (Figg. 1 and 2).

After medial arthrotomy, the stifle were explored to verify the CCL and meniscal conditions. We found 28 cases (78%) of complete rupture and 8 cases (22%) of partial rupture, with medial meniscal damage in 8 cases (22). In 1 case we found a medial femoral condyle OCD. In 12 cases a meniscal release was performed following the Slocum technique (Tab. I). The proximal medial part of the tibia is then prepared, by subperiosteal elevation, starting close to the tibial tuberosity with respect to the small synovial bursa sometimes present under the patellar ligament. The dissection is continue until the medial collateral ligament is found. On the tibial tuberosity, immediately posterior to the cranial cortex, a number of holes corresponding with those on the plate are drilled, by mean of a designed jig, taking care the proximal hole correspond to the physeal scare of the tibial plateau, palpable like a little bone step.

The tuberosity osteotomy is then started, starting half a way the length between the two series of holes on the plate. This osteotomy starts bicortical in the distal one third and monocortical in the proximal two third, taking as proximal landmark the anterior part of the tuber Gerdii, that is to be avoided not to damage the extensor pedis longus tendon. On the chosen plate a special fork is then inserted, with the teeth laterally and ventrally directed, and hammered in the tibial tuberosity, taking care to reach a good bone-plate contact. The osteotomy is then complete bicortically also in the proximal part (Fig. 3). The osteotomized tibial tuberosity is shift laterally, to gain access to the proximal epiphysis where a large amount of cancellous bone is collected. Then a titanium cage, long enough to take contact with both the medial and lateral cortices and of the desired width (6, 9 or 12 mm), is placed in the proximal part of the osteotomy. The cage is provided with two holes for 2.4 self-tap-

Tab. I. Distribution of the subjects and type of lesion.

Size: S-small, M-medium, L-large, G-giant
Type of lesion: C-complete, P-partial
Associated meniscal lesion: P-present, NP-normal, not present

Breed	Size	Sex	Age at Surgery	Affected limb	Type of lesion	Associated meniscal lesion	Meniscal release
Beagle	S	F	7 A	L	P	NP	Yes
Boxer	M	F	1 A	L	C	NP	No
Boxer	M	F	2 A	R	C	P	No
Cane Corso	L	M	2 A	L	C	NP	No
Cane Corso	L	F	4 A	R	P	NP	Yes
Dobermann	L	F	5 A	R	P	NP	No
Dogue De Bordeaux	L	M	3 A	L	C	NP	No
German Sheperd	L	M	8A	L	C	P	No
Golden Retriever	L	F	5 A	L	P	NP	No
Golden Retriever	L	M	5 A	L	P	NP	No
Golden Retriever	L	M	5 A	L	C	NP	No
Labrador Retriever	L	M	1 A	R	C	NP	No
Labrador Retriever	L		2 A	R	C	NP	Yes
Labrador Retriever	L	F	2 A	L	C	NP	Yes
Labrador Retriever	L	M	1 A	L	C	NP	Yes
Mastiff	G	F	3 A	R	C	P	No
Mastiff	G	M	4 A	R	P	P	No
Mastiff	G		3 A	L	C	NP	Yes
Mongrel	M	F	5 A	L	C	NP	No
Mongrel	M		7 A	L	P	NP	No
Mongrel	L	M	9 A	L	C	P	No
Mongrel	M	M	7 A	R	C	NP	Yes
Mongrel	S	M	13 A	L	C	NP	Yes
Mongrel	M	M	2 A	R	C	P	Yes
Newfoundland	G	M	5A	R	C	NP	No
Newfoundland	G	M	4 A	L	C	NP	No
Pastore Maremmano	L	F	2 A	L	C	NP	No
Pittbull	M	F	3 A	L	C	NP	No
Pointer	M	M	4 A	R	C	P	No
Poodle	S	M	9 A	L	C	NP	No
Riesenschnautzer	G	M	9 A	L	C	NP	No
Rottweiler	L	M	1 A	L	P	P	No
Rottweiler	L	F	2 A	L	C	NP	Yes
Rottweiler	L	F	3 A	L	C	NP	Yes
Rottweiler	L	M	7 A	L	C	NP	Yes
Siberian Husky	L	M	10 A	R	C	NP	No

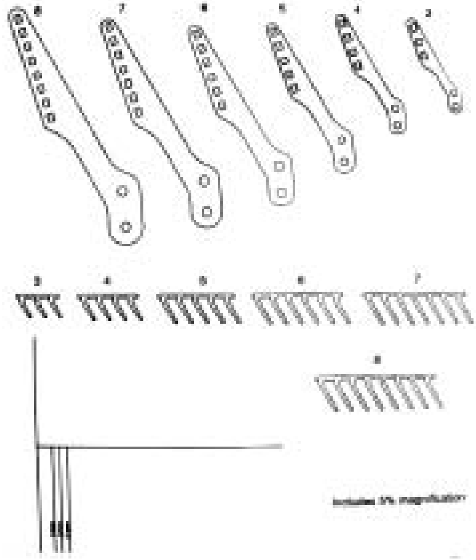

Fig. 1. The TTA planning guide. Top: size of plates. Medium: the forks. Bottom: the mask for the planning of Tuberosity advancement.

Fig. 2. The mask in place. The orizontal line correspond to the tibial plateau. The vertical plane originate at the patellar tendon insertion (top). The vertical parallel lines (bottom) correspond to the amount of tuberosity advancement (9 mm in this case).

Fig. 3. Choosing the plate.

Fig. 4. The plate is inserted. The osteotomy line is visible (arrowheads).

ping titanium screws; these hole are turned on, in ventral direction the caudal one and in dorsal direction the cranial one, to fit the cortices of the tibial epiphysis and of the tuberosity respectively. The osteotomized tuberosity is then replaced over the cage and fixed in position with a reduction forceps, taking care that the distal tuberosity contact the tibial cortices few millimetres above the osteotomy site. Four screws are placed in the cage holes and in the distal plate holes, following the order shown in Fig. 4.

The cage and the remaining osteotomy gap are filled with cancellous bone.

The pes anserinus tendon and the tibial fascia are reconstructed, mobilizing the distal fascia to fill the space made with the tuberosity advancement.

No bandage is used in the postoperative period. All patients were maintained at controlled activity, reduced to short walk on leash, gradually increasing, for the first 6-8 weeks, after which a radiographic control was taken to verify the osteotomy recovery. The patients then start with gradual restore of the normal activity.

RESULTS

In every subject a slight local oedema was noted, but solved spontaneously in four days. Already in the 2nd postoperative day all subjects were able to walk on the operated leg, and this positive trend continue until the 10th-15th day post surgery. The increase in leg activity, always present, slow its progression, but never with regression. After 6-8 weeks 27 subjects (85%), showed a almost normal gait, with weight bearing, preserved RON and negative sit test. The cranial drawer sign was still present, while the cranial tibial trust was negative. The radiographic exam showed always a good bone formation, with the exception of one case where the tibial tuberosity was fixed too cranially, and the residual gap was not completely filled with bone. A further two week period of rest allow for a complete callus formation. At the 12th week 32 subjects gained a normal gait.

One intraoperative complication was recorded, caused by a bad alignment of the fork holes. In this case, the not parallel alignment of the fork with the cranial cortices lead to a too caudal position of the distal holes of the plate. The osteotomized tuberosity was then fixed in a more cranial position, with the declared delay in osteotomy consolidation.

One postoperative complication was recorded, in a 1 year old Labrador Retriever where the CCL rupture was associated with a medial femoral condyle OCD. The big OCD fragment removed during surgery lead to a medial compartment collapse with a varus deviation, and subsequently a medial patellar luxation developed. A first attempt to restore a normal function with a lateral retinacular embrication failed following the rupture of the sutures and a periarticular synovial fluid infiltration. At the moment the patellar luxation is still present and a corrective osteotomy is scheduled.

DISCUSSION

The tibial tuberosity advancement as a solution to the stifle instability following CCL rupture shows, in our opinion, interesting features, some limitations and other aspects to consider after a long term follow-up.

The most interesting feature is represented by the relative simplicity of this technique, that require a common orthopaedic instrumentation. The tibial tuberosity osteotomy requires only an oscillating saw and, fixed the necessary landmarks, do not show particular troubles. The osteotomy need to take care of few aspects:

preservation of tuber Gerdii, not to risk to damage the extensor digitorum longus tendon start with the monocortical osteotomy in the proximal tuberosity, to allow a safe insertion of the plate and fork complex (the fork need to be hammered to gain a good plate-bone contact) the osteotomy must be caudal enough to leave a bone fragment large enough to reduce the risk of fracture the distal part of the osteotomy must start between the distal hole for the fork and the proximal hole of the plate (Fig. 3). This reduce the risk of fissuration of the tibial diaphysis and avoid to create critical point of force discharge, potentially causing complicating fractures.

The holes for the fork must be drilled immediately caudal to the anterior cortex of the tibial tuberosity, to fit the fork in the harder and stronger bone of this region. Too anterior hole can weaken the cranial cortex, while too posterior ones lie in too soft bone; in both cases fractures can occur.

The invasiveness of the technique seems to be lesser with respect to TPLO, and no particular training is required.

The limits seems to be related to the difficulty to correct greater angles of tibial slope and problems in limb alignement. Limb alignement problems subsequent to the TTA could be difficult to correct because of the cage embedded in the new bone, and thus difficult to remove.

Nothing could be say about the meniscal release, performed in 12 of the 33 subjects. This technique, born with the TPLO to avoid the potential femoral-meniscal conflict induced be the tibial plateau realignment, seemed to be not necessary when the TTA started. More recent observation (unpublished data) seem to demonstrate that a greater freedom of motion of the medial meniscus could lead to a lesser incidence of relapse of lameness in the postoperative period. The problem is still open and matter of debate.

OA progression, usually assumed as a parameter for the evaluation of the CCL ligament reconstruction techniques, seems to be really limited, also if the small number of cases and the short follow up do not allow us to reach a conclusion. In the next 2-4 years, when more clinical and radiological data will be available, more informations could be furnished.

At the moment, to the Author’s knowledge, no studies with force plate analysis are available; further studies with this kind of tests will give us interesting informations.

From a clinical and surgical point of view, the TTA shows many interesting points with respect to other techniques, with the advantage of its relative simplicity with respect of the modern biomechanical concepts. Non the same could be said about its versatility, cause at the moment examples of correction of more complex limb deformities associated with CCL rupture are not reported.

Time effects, especially for what attain the restore of the limb function and the stop in the OA progression, are to be completely evaluated.

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