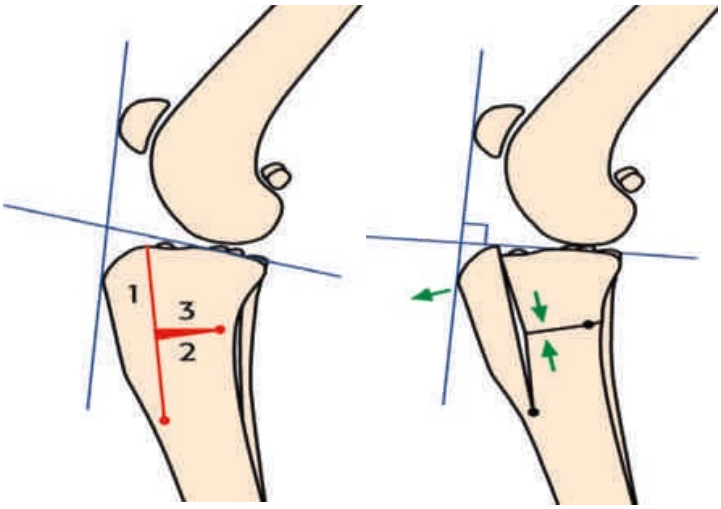
Vi Veterinary Instrumentation

PAN VET

Surgery Guide

TTO (Triple Tibial Osteotomy)

Surgery Guide:
TTO



This procedure is based on biomechanical analysis performed by Dr Slobodan Tepic, which revealed that in order to remove the shear strain from the cranial cruciate ligament, the tibial plateau should be perpendicular to the patellar ligament. There are two ways to achieve this; i) advance the tibial crest (the basis of the Tibial Tuberosity Advancement (TTA) technique described by Professor Montavon) and ii) alter the alignment of the tibial plateau to the patellar ligament to 90° (a modification of the Slocum technique). Dr Warrick Bruce reasoned that rather than doing one technique or the other, there is merit in doing a little of both to achieve the same outcome, but with less radical angular changes. In the Triple Tibial Osteotomy (TTO) procedure, a partial tibial crest osteotomy and small closing wedge osteotomy are performed; closing the wedge simultaneously advances the tibial crest (see figures above).

Contents

- Pre-Operative Patient Assessment
- Pre-Operative Radiographic Assessment
- Pre-Operative Radiographic Calculations
- Surgical Technique
  - Patient Positioning
  - Mini Medial Arthrotomy
  - Instruments & Implants
  - TTO Surgery
- Post Operative Care Instructions

Pre-Operative Assessment

1. Pre-Operative Patient Assessment

Every patient is assessed for the degree of lameness, overall alignment of the limb, stifle range of movement, as well as the degree of stability within the joint.

2. Pre-Operative Radiographic Assessment

Standard medio-lateral and cranio-caudal views of stifles are required. The stifle is positioned in extension for the medio-lateral view (fully extending the joint without forcing it) (Fig. 1).

Fig. 1

This is achieved by securing the upper contralateral limb cranially so that the paw of this limb is positioned up near the dog's ear. Ensure that there is no cranial subluxation of the tibia (however, with this degree of stifle extension the collateral ligaments should be tight and therefore the tibia should not be subluxated but, when in doubt, compare it with the contralateral side). The hip is packed up and the femur and tibia positioned parallel to the plate.

Ideally, in the medio-lateral view, the femoral and tibial condyles should be superimposed on top of each other. Sometimes this is very difficult to do! We have performed cadaver studies, in large breed dogs, looking at the effects of limb positioning on the apparent radiographic position of the tibial plateau (TP) and comparing this with its true anatomical position. These studies showed that there was little effect on the radiographic position of the TP if the femoral and tibial condyles were superimposed with less than 3mm of disparity in any direction. When there was 3mm or more disparity in cranio-caudal superimposition, tibial condylar mal-alignment introduced more errors in determining the position of the TP than femoral condylar malalignment. However, alignment in the proximo-distal plane was the most critical as valgus or varus positioning of the stifle introduced the most errors in determining TP position.
The X-ray beam should be centred at the tibial plateau. The exposure should be coned-down to the area of the stifle. There is no need to include the hock joint.

3. Pre-Operative Radiographic Calculations

A summary of the pre-operative radiographic calculations is as follows:

Line 1:
Define the position of the tibial plateau (TP) (line 1) (Fig. 2). This is done by estimating the position of the surface of the medial tibial condyle, which is slightly convex in shape. There are two ways in which this can be done:

- The conventional method determines the location of the TP by identifying the cranial and caudal points and drawing a line between them. The cranial-most point of the medial tibial condyle is visible as a small discrete step. The caudal point is the point of insertion of the CaCL -the apex of the popliteal notch is a useful point of reference. In some osteoarthritic stifles, osteophyte formation can obscure these landmarks and in these cases the tangential method may be more useful.
- In the tangential method a line is drawn tangential to the convex surface of the medial tibial condyle at the point of contact between the medial femoral and tibial condyles.

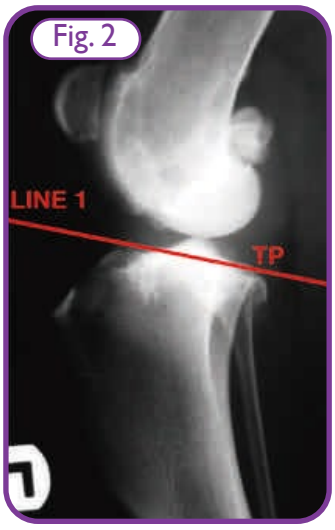


Fig. 2

It should be noted that the Tibial Plateau Angle (TPA), although of interest in other tibial plateau adjusting techniques, is not involved in calculations used in the TTO. The important relationship in the TTO technique is that between the tibial plateau and the straight patella ligament.

Line 2:
Draw a line marking the cranial edge of the straight patellar ligament (PL) (Fig. 3). Position a straight edge cranial to the stifle and slide it caudally until it first touches points on the patella and the tibial crest. The distance between these points is the patellar ligament length (line 2). Measure and record the length of line 2. In this patient it measured 60mm.

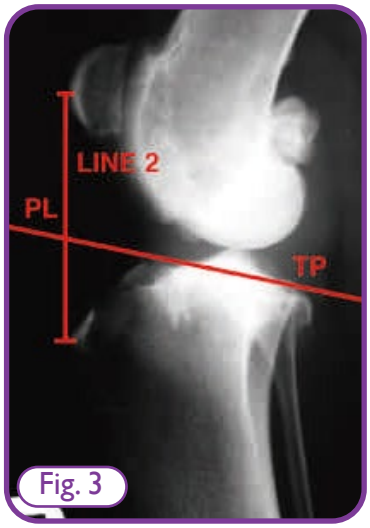


Fig. 3

Tibial crest osteotomy (TCO):
Mark a point (at the endosteal surface of the cranial cortex of the tibia) exactly the length of the patellar ligament (line 2) distal to the patellar ligament insertion on the tibial tuberosity. This point marks the distal end of the tibial crest osteotomy (TCO). Draw the tibial crest osteotomy line (TCO). (Fig. 4) Generally the TCO is made parallel to the axis of the tibial shaft and is usually parallel to the cranial aspect of the tibial crest. Its proximal end should terminate within the non-articular part of the proximal tibial, caudal to the patellar ligament insertion and cranial to the cranial edge of the menisci. Measure and record the length of the TCO in mm-in this patient it measured 70mm.

Fig. 4

Define the wedge position:
Create line 3 by drawing a line perpendicular to line 1 (TP) starting from the proximal end of line 2. Measure the correction angle (CA) in degrees using a protractor. The CA is the angle between lines 2 and 3. In this patient the angle measured 12°.

Calculate the wedge angle (WA) by using the formula: **WA = (0.6 x CA) + 7**

The central axis of the wedge is located exactly halfway along the TCO. Draw in the central axis of the wedge as a line extending caudally and perpendicularly from the TCO line at its mid point. The wedge to be resected is centred on this line; the apex of the wedge is located at the endosteal (cranial) surface of the caudal tibial cortex. The base of the wedge is located at the TCO with each side of the wedge equidistant (proximally and distally) from the central axis. The calculated wedge angle in this patient was 14° (Fig. 5).

Fig. 5

Surgical Technique

1. Patient Positioning

The patient is positioned in dorsal recumbency for the initial part of the surgery, which is to explore the medial aspect of the stifle joint.

2. Mini Medial Arthrotomy

Identify patellar tendon between the distal patella and the tibial tuberosity; work medial to it.

- Make incision into medial retinaculum and then joint capsule, place stifle distractors and Gelpi retractors.
- The mini medial arthrotomy extends from distal pole of the patella distally to the fat pad /proximal tibia. The thick medial patellar fibrocartilage medial to the patella is NOT transected.
- Inspect cranial cruciate ligament and debride mechanically incompetent portion; leave any mechanically component portions.
- Inspect medial meniscus for tears and resect/ remove any damaged tissue; otherwise leave normal meniscus alone.
- Inspect the lateral meniscus and caudal cruciate ligament and document; these are almost never affected other than some fibrillation of the visible portion caudal cruciate ligament.

It is normal for the axial (medial) thin edge of the medial meniscus to have a folded undulating appearance; this is NOT a meniscal tear.

If the cranial cruciate ligament is mostly intact, it may be very difficult to inspect much of the medial meniscus as the cruciate ligament is directly in front of this; inspect as much of the meniscus as you safely can and if no damage is seen, it can be assumed that the meniscus is not torn/damaged given the cruciate ligament is present and competent.

Do not make a meniscal release or transection; this procedure is outdated and no longer performed by most surgeons. Releasing or cutting the meniscus means it loses its mechanical integrity and likely induces DJD in the stifle

- Lavage the joint space and partially close the capsule and fascia together in one layer using monofilament absorbable sutures (PDS or similar) in a cruciate pattern.

3. Instruments and Implants

There are dedicated instruments designed to simplify the operation and improve accuracy (Fig. 6a). There is a revised TTO saw guide with a 1.9mm guide pin; the revised guide is designed to lock into the revised TTO osteometer, which is used for the wedge cut. The TTO wedgie is used to hold the TCO open while the wedge is cut and reduced. The revised TTO clasper is used to secure the combined saw guide and osteometer to the bone and to provide a point of fixation for the large fragment forceps during reduction of the wedge osteotomy (Fig 6b and Fig. 6c).

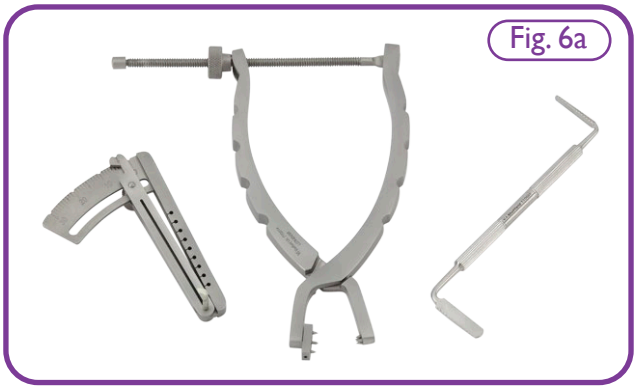


Fig. 6a

Fig. 6b

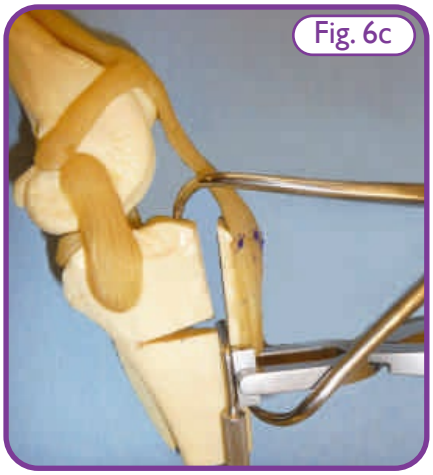


Fig. 6c

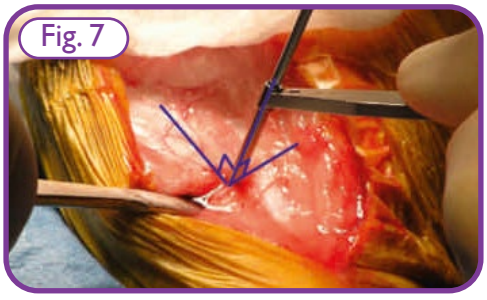
Use the Vi angle finder and overlay to select a plate offering the best fit for the caudal two thirds of the proximal tibia. Typically dogs weighing less than 35kg, require a medium Vi TPLO plate (TPLO353557 or TPLO353555). For larger dogs use Vi TPLO plates (TPLO353579 or TPLO353562). Smaller plates are available for dogs less than 20kgs. It is recommended that the appropriate size of plate is pre-contoured by twisting the proximal portion of the plate 10-15° towards the midline.

4. TTO Surgery

With the patient now in lateral recumbency with the affected leg down and parallel to the operating table, the crural fascia is reflected from the medial aspect of the tibia, taking care to preserve the saphenous blood vessels distally and the medial collateral ligament proximally. An appropriately sized pre-contoured TPLO plate is placed against the medial surface of the tibia to check that the plate is adequately contoured. Adjust the plate accordingly.

Using a surgical ruler, measure the predetermined PL length (line 1) from the distal end of the patellar ligament distally along the cranial edge of the tibia. Mark the level of the distal extremity of the TCO with a bone scribe. The distal point of the TCO is located at this level but just caudal to the cranial cortex of the tibia (i.e. at the endosteal surface of the cranial tibial cortex). Check that there is enough room caudal to this point to apply the selected plate.

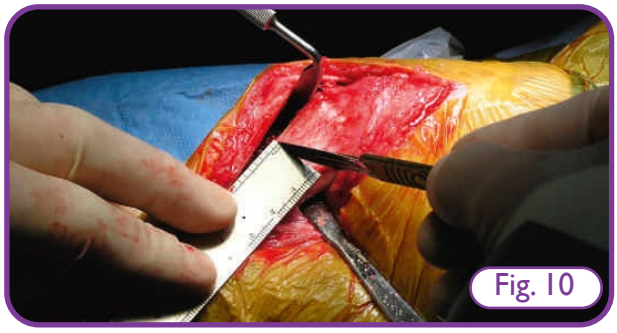
A 2mm hole is drilled at right angles to the sagittal plane of the tibia (Fig. 7). Note that the tibia slopes cranially in this area and if the distal TCO hole is mistakenly drilled at right angles to the surface of the tibia then the TCO will be orientated in a cranio-medial to caudo-lateral direction. This orientation is incorrect and could result in damage to structures on the lateral side of the tibia (eg the long digital extensor tendon and sheath).



The pin on the TTO Saw guide is then inserted into this hole and the saw guide is aligned parallel to the tibial crest (Fig. 8). Compare the position of the proposed TCO cut to the pre-operative radiographic plan. Double check that the dimensions and orientation of the TCO are the same as your radiographic plan.

The TCO is completed with an oscillating saw from the distal hole in the tibia proximally into the joint (Fig. 9). Ensure the patellar ligament is protected at all times and that there is copious lavage of the saw blade to prevent thermal necrosis of bone. The saw guide is useful to cut the bulk of the TCO however the final distal cut into the guide hole and the most proximal part of the cut are usually done free-hand. The TCO is checked to ensure that the osteotomy is complete.

The length of the TCO is measured. A point halfway along the TCO is marked and the wedge centre line is then scribed in the bone at right angles to the TCO. An orthopaedic ruler can be used as a set-square to achieve this accurately (Fig. 10). Invariably this line transects the base of the medial collateral ligament and is located about one third of the distance up from the distal end of the tibial crest.



The origin of popliteal muscle is elevated from caudal aspect of the tibia in the area adjacent to this mark. A small Hohman retractor and a dry surgical swab are used to retract the soft-tissues at this point to prevent iatrogenic damage to the cranial tibial artery, located within the soft tissues lateral to the osteotomies (Fig. 11).

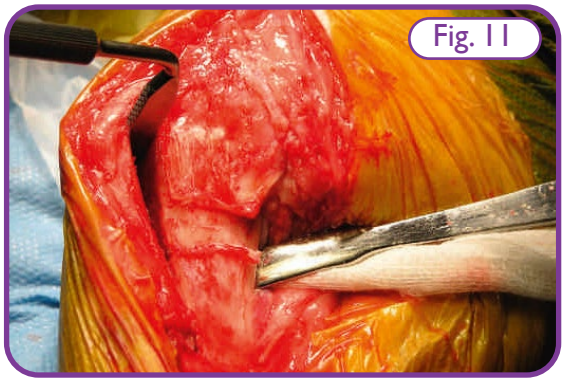


Fig. 11

The proximal part of the TCO is then **carefully** and **slowly** forced apart using a periosteal elevator. Hinging the tibial crest forward like this will allow the insertion of the large blade of the TTO wedgie proximally, or alternatively, the small blade of the TTO wedgie more distally. The wedgie is then carefully rotated, levering the tibial crest cranially, to give the maximal amount of tibial crest advancement. In some smaller dogs, it may be easier to position the larger blade of the wedgie more proximally when performing the wedge ostectomy procedure. However, in all cases, the wedgie must be positioned **distal** to the wedge ostectomy during the closure of the wedge.

A 2mm drill hole is placed at the caudal end of the wedge centre line. Its location is usually at the level of the endosteal surface which is located 2-3mm inside the caudal cortex of the tibia. As the bone in this region slopes away caudally, it is necessary to start drilling perpendicular to the bone surface until the drill bit engages the bone (Fig. 12a). Once this occurs the drill is then aligned perpendicular to the medial surface of the tibia (Fib. 12b).

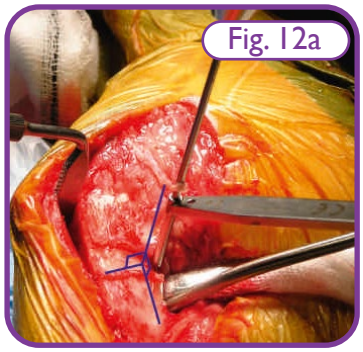


Fig. 12a

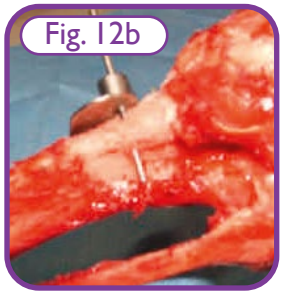


Fig. 12b

The caudo-medial anatomy of tibia in this area is ridge shaped, which means that the guide hole exits this ridge in the caudal region of the tibia. It is worth spending some time studying anatomical specimens and working out where everything is, prior to completing this location hole. When this is completed, the pin on the saw guide is inserted into this drill hole and aligned along the marked centre line. If the location hole has been drilled perpendicular to the tibial surface, the saw guide should lay flat along the medial surface of the tibia. If using original TTO equipment, the hooked end of the TTO osteometer is placed between the saw guide and the tibia, and hooked behind the saw guide pin. For revised equipment, the osteometer is hooked behind the saw guide pin by feeding it through the transverse central slot within the guide. Both the original and revised osteometers are marked on both sides and once hooked on should sit **distal** to the saw guide (Fig. 13).

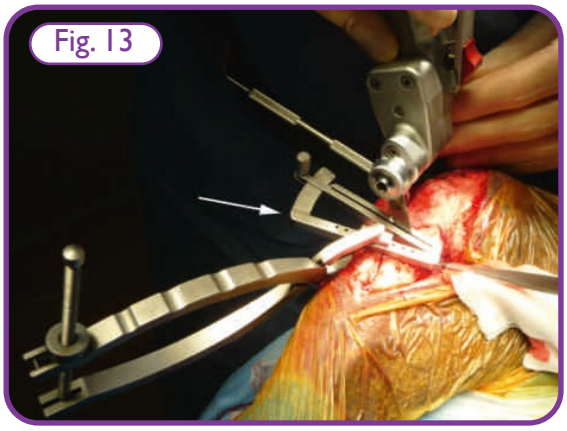


Fig. 13

The saw guide is aligned and set to half the wedge angle. For example, if the calculated wedge angle (WA) is 12° then the osteometer is rotated until half of this angle (i.e. the 6° mark) is positioned at the wedge centre line (and the centre of the slot in the saw guide). The osteometer is fixed in this position by either inserting a 1.4/1.6mm K-wire into the tibia through one of the fixation holes in the osteometer, or by using a pair of pointed reduction forceps to grasp the tibia whilst one point of the forceps is inserted into a fixation hole. When using the revised equipment, a specially designed TTO clasper locks into the fixation holes on the osteometer and its alligator jaws securely fix it to the tibia.

The saw guide is then aligned alternatively with the 0° and 12° marks on the osteometer to create the appropriate sized wedge. With the original equipment the saw guide needs to be held manually in the correct position however the revised saw guide has a knurled fixation nut which, when tightened, secures the guide to the osteometer. Alternatively the revised saw guide can be locked at the mid point (for example 6°) and then the osteometer and saw guide unit is positioned at right angles to the TCO before being secured by the clasper. Once secure, the knurled nut is released allowing the guide to be positioned for each cut.

A fine saw blade is used to cut a full thickness wedge from the proximal tibia (Fig. 14).

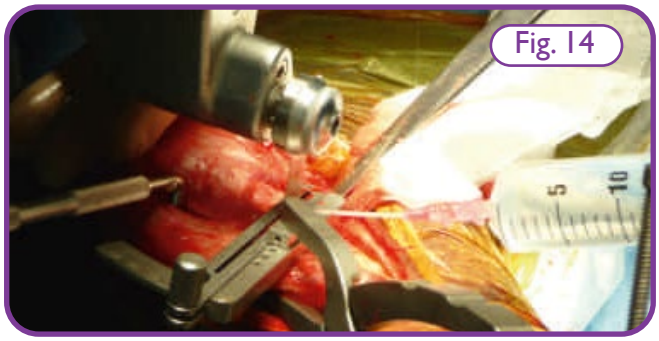


Fig. 14

The slot in the saw guide is 1.0mm so it is important that the blade cut (the width at the teeth) is less than 1.0mm. The oscillating saw blade is rested against the outer surfaces of the saw guide slot when cutting the wedge. Take care to ensure the cuts are made in parallel planes. Once the cis cortex is cut, the saw blade is orientated in a slightly cranial direction and the cranial part of the lateral tibial cortex is cut. Then the saw blade is orientated slightly caudally to cut the caudal and caudo-lateral parts of the lateral tibia. This blade orientation will ensure smooth cuts are made evenly through the lateral cortex.

The cuts should enter the caudal locating hole, so once the wedge cuts are complete and the saw guide is removed, the saw blade is used to extend the cuts caudally into the locating hole. The wedge is removed and the tibial ostectomy checked to ensure that there are no bone ledges or edges left behind. Store the wedge in a blood soaked swab so that its cancellous part can be used as an autogenously bone graft later. The gauze swab and the retractor placed caudal and lateral to the tibia are removed.

The TTO clasper is used to grasp the tibial crest distal to the wedge ostectomy (alternatively a pair of Kern forceps can be used). One point of a pair of large spinlock fragment forceps is inserted into the non-articular cranial aspect of the stifle joint. The other point is hooked into the fixation hole in the end of the TTO clasper foot (Fig. 15a and Fig. 15b).

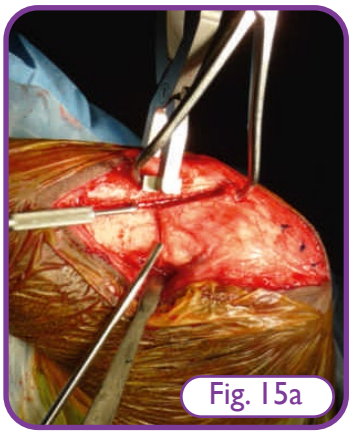


Fig. 15a

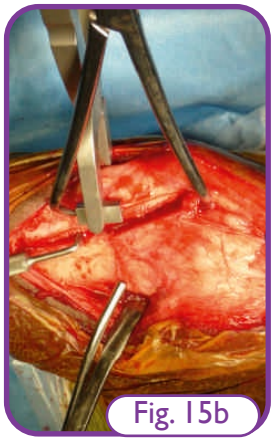


Fig. 15b

When using Kern forceps, the fragment forceps engage the upper jaw of the Kern. The tibial wedge ostectomy is then gradually closed by using a combination of tightening the spinlock nut and applying upward pressure on the foot (tibial thrust action). The resultant action serves to gradually close the gap but at the same time keeping the caudal tibial cortex intact.

Closing the tibial wedge causes the tibial plateau to rotate cranially which serves to hold the tibial crest in its new advanced location. If it is difficult to completely close the wedge it may be necessary to re-cut the apex of the wedge near the locating hole. Once the wedge ostectomy has been closed, the plate is rechecked and any necessary moulding adjustments are made. The plate is then fixed to the bone using cortical screws using standard AO techniques (Fig 16a and Fig 16b).

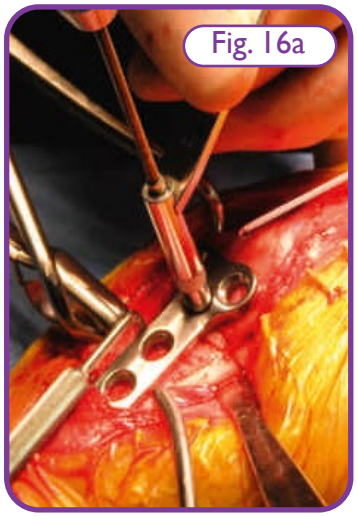


Fig. 16a

Fig. 16b

Cancellous screws can be used in the most proximal two holes without prior tapping if the cortices are very thin (eg in older German shepherd dogs). The load guide can be used to apply axial compression. Cancellous bone harvested from the resected wedge is used as a bone graft and placed into the triangular space left caudal to the tibial crest.

Following wound lavage, the fascia and the rest of the joint are closed with monofilament absorbable sutures (eg PDS). Bupivicaine (Marcain, 2mg/kg) or a mixture of bupivicaine and morphine (0.1mg/kg) can be injected into the stifle joint and beneath the crural fascia at this time.

If the tibial crest (TC) fragment fractures at its distal hinge point, then the TC is stabilized using a single K-wire and a tension band wire passed in a fig-8 pattern between 1.5mm diameter holes drilled about 10mm proximal and distal to the fracture. In most cases, stable TCO fractures will be adequately stabilized by closing the surrounding soft tissues.

The remaining soft tissues are closed in a routine fashion. Post-operative radiographs should be taken to assess bone alignment and implant position (Fig. 17a and Fig. 17b).

Fig. 17a

Fig. 17b

Post-operative Care Instructions

Medications:
The following medications are suggested:
A NSAID is used for a minimum of 7 days.
Post operative antibiotics are at the discretion of the veterinary surgeon.

Exercise
Crate rest is required for the first 6 weeks following TTO surgery. The only exercise allowed is short-duration (5 - 10 minutes maximum), slow walks on a leash for toileting purposes. Walking up and down flights of stairs, jumping up, or any uncontrolled activity must be avoided. Take care to avoid slipping when walking on wet or smooth surfaces. An old towel can be used as a hind-quarter sling placed underneath the abdomen if necessary.

Physiotherapy
Postoperatively, physiotherapy in the form of passive range-of-motion exercises can be performed under supervision of a veterinary physiotherapist.

Longer-term follow-up and care
Radiographs at 6 weeks post-op are recommended, to assess the progress of healing. All going well, controlled exercise on a leash may begin at this time. Leash walks should be minimal at first and then gradually increased after 8 weeks post-operatively. Sit/stand exercises should also begin around 6 weeks post-operatively. There should be no unsupervised exercise, and running and jumping should be avoided during the 6 to 12 week post-operative period. Between 8 and 12 weeks, exercise can be increased slowly to 30 to 40 minutes twice daily. Hydrotherapy is excellent therapy at this stage.

By 12 to 16 weeks the patient should have returned to near-normal activity. However, there is a large variation in how quickly individuals return to full function following TTO surgery.

Special thanks to Warrick Bruce and Geoff Robins for their preparation of the original version of this Surgery Guide.

Featured Products

Vi supply a full range of TTO instrumentation. You can shop the range by scanning the QR code:

Original TTO Instrumentation

TTO006 Basic Osteometer
TTO004 Saw Cutting Guide (Standard 62mm)
TTO002 Wedgie Segment Manipulator

Revised TTO Instrumentation

TTO011 Combination Osteometer/Sawguide
TTO014 TTO Clasper
TTO002 Wedgie Segment Manipulator
TTO009 Enhanced TTO Instrument Set (All of above)

TTO Plates

The Standard TTO Plate is a cloverleaf TPLO Plate. Being positioned over the caudal 2/3 of the tibia the plate selected is typically a little smaller than is the case with a wedge TPLO. Use the free plate overlay for the final selection. Thicker plates are harder to contour & a selection of pre-contoured plates are available.

TPLO202026 2.0mm DCP 26mm Overall Length
TPLO202031 2.0mm DCP 31mm Overall Length
TPLO242434 2.4mm DCP 34mm Overall Length
TPLO242441 2.4mm DCP 41mm Overall Length
TPLO272739 2.7mm DCP 39mm Overall Length
TPLO272745 2.7mm DCP 45mm Overall Length
TPLO273539 2.7/3.5 DCP 39mm Overall Length
Allows Use Of 3.5mm Cancellous Screw In Head
TPLO273545 2.7/3.5 DCP 45mm Overall Length 2.5mm Thick
TPLO353555 3.5mm DCP 55mm Overall Length
TPLO353557 3.5mm DCP 57mm Overall Length Heavy Duty
TPLO353559 3.5mm DCP 59mm Overall Length
TPLO353562 3.5mm DCP 62mm Overall Length
TPLO353565 3.5mm DCP 65mm Overall Length
TPLO353577 3.5mm DCP 77mm Overall Length
TPLO353577X 3.5mm DCP 77mm Overall Length Extra Shaft Hole
TPLO353579 3.5mm DCP 79mm Overall Length Heavy Duty
TPLO354579 3.5/4.5 DCP 79mm Overall Length Heavy Duty
Allows 4.5mm Screws In Head
TPLO35456579 79mm Overall Length Heavy Duty
Allows 4.5/6.5mm Screws In Head
TPLO45659030 4.5mm DCP 90mm Overall Length
Will Accept 6.5mm Cancellous Screws In Head 3.0mm Thick
TPLO45659035 4.5mm DCP 90mm Overall Length
Will Accept 6.5mm Cancellous Screws In Head 3.5mm Thick
TPLO45659045 4.5mm DCP 90mm Overall Length
Will Accept 6.5mm Cancellous Screws In Head 4.5mm Thick
TPLOO Angle Finder & Plate Overlay

Pre-Contoured TTO Plates

TPLO353555PCR 3.5mm Plate 55mm Overall Length Right
TPLO353555PCL 3.5mm Plate 55mm Overall Length Left
TPLO353557PCR 3.5mm Plate 57mm Overall Length Right
TPLO353557PCL 3.5mm Plate 57mm Overall Length Left
TPLO353579PCR 3.5mm Plate 79mm Overall Length Right
TPLO353579PCL 3.5mm Plate 79mm Overall Length Left

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