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Complications of tibial plateau levelling osteotomy in dogs

M. S. Bergh[1]; B. Peirone[2]

[1]Iowa State University College of Veterinary Medicine, Ames, Iowa, USA; [2]School of Veterinary Medicine, University of Turin, Turin, Italy

Keywords

Cranial cruciate ligament rupture, complication, surgery, review, outcomes

Summary

The tibial plateau levelling osteotomy (TPLO) is one of the most common surgical procedures used to treat cranial cruciate ligament disease in dogs. Complications occur- ring during or after TPLO can range in severity from swelling and bruising to fracture and osteomyelitis. Ten to 34% of TPLO surgical procedures are reported to experience a complication and approximately two to four percent require revision surgery to address a complication. Although the risk factors for many complications have not been fully assessed, the best available evidence suggests that complications of TPLO can be reduced with increased surgeon experience, careful surgical planning, and accurate execution of the surgical procedure. Identification of known or suspected risk factors and intra- operative technical errors allow subsequent action to be taken that is aimed at decreasing postoperative morbidity. There is a need for prospective studies with consistent data reporting in order to fully reveal the incidence risk factors for complications associated with TPLO.

Introduction

Cranial cruciate ligament (CCL) disease is one of the most common conditions causing lameness in both small and large breed dogs (1). Over sixty operative techniques have been described to treat the condition, and currently, the tibial plateau levelling osteotomy (TPLO) is one of the most widely performed of these procedures (2–7). The TPLO procedure was first de- scribed in 1993 and since that time, numerous studies have reported the outcome and complications of the procedure (8). Re- ported complication rates range from 10–34%, and complications vary in severity from swelling and bruising to fracture and osteomyelitis (2–8). The TPLO procedure has the potential to have complications that are shared among all orthopaedic surgical procedures, complications that may be directly related to the patient or the surgeon, and complications that are directly related to the procedure itself. Such intra-operative or postoperative complications may involve soft tissues, bone, implants, or a combination of these factors (Table 1 and 2).

The aim of this report was to critically review and analyze the scientific literature reporting complications associated with standard TPLO in dogs, with particular emphasis on incidence and risk factors, where data are available. Scientific literature published in the English language and reporting complications of TPLO were re-viewed.

Soft tissue complications

Errors in surgical approach or technique may lead to unnecessary soft tissue trauma including laceration to the regional blood vessels, patellar tendon, medial collateral ligament, and the long digital extensor ten- don (2, 3, 9). Significant intra-operative haemorrhage associated with laceration of the popliteal artery or the cranial tibial artery has been reported to occur in less than one percent of TPLO surgical procedures (2–4, 10) (Table 1). When haemorrhage from a lacerated vessel or the nutrient artery is encountered, it may be severe and it must be controlled with digital pressure, clotting agents, ligation, or a combination of these. In order to help reduce this specific complication, the original description of the TPLO technique advocated isolating the proximal tibia by placing gauze sponges between the tibia and popliteal muscle (8). The effectiveness of this technique was not supported by the findings of a cadaveric angiographic study, however *in vivo* studies are lacking (11).

Soft tissue elevation and introduction of gauze sponges between the proximal tibia and the surrounding musculature has been shown to decrease iatrogenic trauma to the caudoproximal and cranioproximal tibial muscle groups by the TPLO saw blade (8, 12). While effective, this soft tissue elevation has been implicated in postoperative luxation of the long digital extensor tendon and the sponges have been shown to leave microscopic debris within the surgical site, which may incite tissue reactions in the patient (9, 12). Inadvertent retention of pieces of sponges or complete sponges can occur and may result in a foreign body reaction including infection or the formation of a draining tract. The use of surgical sponges with radiopaque markers is advised to allow identification of retained sponges on postoperative radiographs (3).

Swelling, bruising, and seroma formation may occur in the short or inter- mediate time period after surgery. While these are generally considered to be minor complications because they do not typically necessitate additional surgical procedures, they may cause significant patient morbidity such as pain and lameness (4, 7, 13, 14). Careful soft tissue handling and closure of dead space, according to Hal- stead's principles, may decrease the incidence of such complications. In one study, it was found that the postoperative application of a modified Robert-Jones bandage was ineffective at reducing limb circumference secondary to swelling within 24 hours of TPLO surgery (15). The intermittent use of cold compression therapy is, however, reported to improve patient comfort, de- crease lameness, decrease swelling and in- crease the range-of-motion in the stifle after TPLO (16).

Reported infection rates following TPLO range from 0.8 to 14.3% (2–5, 14, 17, 18). These rates are generally greater than would be expected for clean surgeries (1.5–2.6%) (19–26) (Table 2). The cause for the higher infection rate is incompletely understood, and likely multifactorial. Excessive soft tissue dissection, increased anaesthetic time, the use of propofol for anaesthetic induction, implant surface properties, and poor soft tissue coverage of the proximo-medial tibia are pro- posed as reasons for increased infection rates after TPLO (20, 21, 27, 28). However, one re- cent study did not find any correlation be- tween duration of anaesthesia or surgery and rate of infection among dogs undergoing TPLO (7).

Soft tissue infections may lead to osteomyelitis if left untreated (21). In order to decrease the risk of postoperative infection, it is recommended that strict aseptic operative techniques should be employed, peri-operative broad-spectrum antibiotics be administered, and that surgery be post-poned for patients with pyoderma present in the region of the surgical site (29). Although specific treatment algorithms have not been formally reported, targeted anti- microbial therapy should ideally be based on culture and sensitivity testing of the tissues around the implant, synovium, or synovial fluid (21, 29). Many soft tissue infections can be successfully treated with appropriate antibiotic therapy alone (2, 3, 5, 7). However, some bacteria form a glycocalyx around the implants, and implant removal may be necessary once the osteotomy has healed, if clinical signs of infection return after cessation of antibiotic therapy (21) (Fig. 1). Although postoperative antibacterial therapy is not indicated for clean surgical procedures, the administration of postoperative antibiotic drugs has been shown to be protective against the development of infection and incisional inflammation in dogs undergoing TPLO (5, 7, 20). Additionally, incisions closed with materials other than stainless steel surgical staples were shown to have a lower rate of incisional infection and inflammation in one study (20).

Postoperative meniscal injury is reported to occur after 0.7–13% of TPLO procedures (2, 7, 13, 30). Meniscal tears are associated with an onset of lameness and they are reported to require a revision surgery to remove or repair the torn meniscus in order for the patient to regain limb function (7, 30, 31, 32). It remains unclear if some meniscal tears that are identified postoperatively may have actually been present at the time of initial TPLO surgery, but were not recognized and treated (30). It has been recommended that careful assessment of the femoral and tibial surfaces of both the caudal pole of the medial meniscus and cranial pole of the lateral meniscus be made both visually and by gentle palpation with a meniscal probe (33). If a tear is identified, the torn portion should be removed (32). One study found that the meniscus may be unknowingly damaged if a hypodermic needle is placed into the joint at the level of the medial collateral ligament (34). This iatrogenic damage may be mis- taken for a tear sustained postoperatively, thus falsely increasing the reported rate of this complication (34). It is recommended that a 25-gauge needle be inserted through the ‘safe zone’ cranial to the medial collateral ligament to reduce the occurrence of iatrogenic meniscal injury (34). With advances in current and new techniques, meniscal repair may be a possibility for some dogs in the future (35, 36). The risks and benefits of performing a medial meniscal release in the prevention of postoperative meniscal injury are debated (5, 30, 31, 37). Meniscal release changes the contact mechanics within the stifle joint, subsequently causing osteoarthritis, and it does not seem to fully eliminate the risk of postoperative meniscal tear (5, 7, 30, 38, 39).

Continued injury of the CCL may occur due to under-rotation of the plateau segment in patients with a non-debrided, partially torn CCL (40). It has been postulated that residual inflammation in the partially intact CCL or subchondral bone may cause continued postoperative lameness in some dogs (41). In these cases, which appear to be over represented in the Boxer breed, resection of the CCL remnants may alleviate pain and lameness (7, 41). Additionally, it is theoretically possible to injure the caudal cruciate ligament with over-rotation of the plateau segment, but the incidence and clinical significance of this complication remain unclear (32, 42). Arthroscopically-confirmed complete rupture of the caudal cruciate ligament has been reported in three dogs after TPLO, in association with over-rotation of the plateau (n = 1) and suspected trauma (n = 2) (32).

Patellar tendon thickening is reported to occur after 80–100% of TPLO procedures and it is typically considered to be a benign change (43, 44). Cranially positioned osteotomies, a partially torn CCL in combination with a cranially positioned osteotomy, and postoperative tibial tuberosity fracture have been identified as risk factors for patellar tendon thickening (43). Patellar tendon thickening can be associated with pain and lameness and thus has been characterized as patellar tendonitis (2, 4, 7, 13, 43) (Table 2). The cause of this clinical complication is thought to be trauma sustained during surgery, increased stress on the patellar tendon due to altered postoperative biomechanics, or exuberant patient activity in the postoperative period (7, 43, 44). Typically, clinical signs of pain and lameness associated with patellar tendonitis resolve with the administration of non- steroidal anti-inflammatory drugs and patient convalescence (43).Sarcoma formation has been reported in or around the stifle joint of dogs that previously had TPLO surgery (21, 45– 47). The causal relationship between TPLO and the development of neoplasia, however, is de- bated and remains unclear. The overlap- ping population of dogs with CCL disease and peri-articular sarcomas is large (2–5, 7, 48). Osteosarcoma, histiocytic sarcoma, and synovial sarcoma have a predilection for the stifle joint, and these tumours commonly occur in middle age to older large breed dogs (48). Some have suggested that metal composition and characteristics, as well as surface inclusions of the Slocum TPLO plate may induce neoplastic trans- formation, however more investigation into this assertion is needed (27, 45, 47, 49).

Bone complications

Tibial diaphyseal fractures (0.04–9% of TPLO procedures) are typically considered a major complication as they often require internal or external stabilization (2, 4, 5, 13) (Fig. 3). There is little written about the risk factors for tibial diaphyseal fractures. How- ever in the authors' experience, the insertion of an over-sized jig pin relative to the patient's tibia or eccentric jig pin placement, close to the tibial cortex, may predispose a patient to this complication. Direct trauma to the tibia sustained after surgery may also cause a tibial diaphyseal fracture (2, 3).

Avulsion fractures of the tibial tuberosity have been reported to occur after 0.4% to nine percent of TPLO procedures (4, 14, 43, 50–52). Tibial tuberosity fracture may be caused by the strong pull of the quadriceps muscles on the patellar tendon that inserts on the tibial tuberosity, geometry of the tibial crest, or the location of the osteotomy (50, 51). The rate of tibial tuberosity fracture is substantially higher when single session bilateral TPLO is performed (22.7% – 40%) compared to unilateral TPLO (0.4% – 5.1%) (7, 50, 51). This equates to a 12.4 times higher likelihood of tibial tuberosity fracture after single session bilateral TPLO (51). A thin craniocaudal thickness of the tibial tuberosity has been shown to be highly correlated with tibial tuberosity fracture and a minimum cranio-caudal tibial tuberosity width of 10 mm is currently recommended (51). Some tibial tuberosity fractures will heal successfully with conservative management, while others with significant tibial tuberosity displacement and instability may require open reduction and internal fixation (2, 3, 18, 50, 51) (Fig. 2).

Patellar fractures are also reported infrequently (0.09–1.1%) after TPLO (7, 43). Fractures are typically located at the apex of the patella and may be caused by altered biomechanics after TPLO. Although they may be considered incidental findings, patellar fractures may also be associated with an acute onset of lameness (5). Conservative management apparently results in fibrous non-union in most cases (7). If the fracture fragment is large, open reduction and internal fixation is indicated (53).

Smaller fracture fragments are unlikely to heal and they may be excised if lameness persists (53).

The development of fibular fractures is reported to occur during (0.1–2.4%) or after (0.4–15%) TPLO surgery (2–5, 7, 18, 52,54,55)(Table1and2).A fracture may occur intra-operatively during plateau rotation if a synostosis or ankylosis exists between the fibular head and the lateral aspect of the tibial plateau (55). Alternatively, fibular fractures may occur postoperatively, concurrent with implant failure, fixation failure, delayed union, or direct trauma (3, 18, 54, 55) (Fig. 1). Postoperative fibular head and neck fractures are suspected to be due to increased stress placed on the proximal portion of the fibula after rotation of the tibial plateau (3, 54). Identified risk factors for fibular fracture include increased patient body weight, increased preoperative tibial plateau angle, larger plateau rotations, and TPLO performed without the use of a jig (54, 55). One recent study of fibular fractures also identified the presence of an unfilled drill hole through the fibula as a risk factor for fibular fracture (55). Interestingly, this study has a substantially higher rate of fibular fracture (15% fracture) in comparison to other studies (0.1–9.1%) although the reasons for this are unclear (3, 5, 54, 55). This study also found that dogs with fibular fracture had a greater postoperative in- crease in tibial plateau angle when com- pared to dogs without fracture (55). This latter finding may support the importance of the fibula in stabilization of the plateau after TPLO, or alternatively, fibular fracture may be a secondary effect of fixation failure (55). Fibular fractures are typically man- aged conservatively unless they are associated with unstable fixation of the osteotomy (18, 54, 55).

The rate of patellar luxation following TPLO appears to be low, and this complication is reported to occur in dogs of any size (5, 56). The underlying cause of the luxation may be due to pre-existing subclinical tibial or femoral varus, or alternatively, tibial torsion or angular deformity created during the TPLO (5, 56, 57). Corrective surgery for patellar luxation after stifle stabilization is reported to be successful in 79% of stifles (56). In that study, patellar reluxation rate was significantly lower when at least one corrective osteotomy (tibial tuberosity transposition, femoral trochlear sulcoplasty or TPLO with tibial axial re- alignment) was performed (56). A careful assessment of varus or valgus deformities is recommended and femoral corrective osteotomy performed if indicated (56, 57). Torsional or angular deformities of the tibia may be introduced by osteotomy position or placement, gap formation at the osteotomy site or malalignment of the tibial tuberosity (5, 9, 42, 43, 58–60). Addition- ally, tibial deformity can develop postoperatively due to implant or fixation failure (18, 55). At a minimum, iatrogenic malalignment of the tibial axis will cause altered cartilage loading and osteoarthritis; in more severe cases it has been reported to cause gait abnormalities, lameness, and patellar luxation (5, 7, 37, 56). To avoid long axis shifts in the tibia, the cylindrical osteotomy must be centred on the intercondylar eminences, and careful attention made to limb alignment prior to stabilizing the osteotomy (61).

Implant complications

Implant-related complications are re- ported to occur in less than 10% of all TPLO procedures (2, 3, 5). Intra-articular placement of a jig pin, Kirschner wire, or screw can cause significant damage to the articular cartilage and may result in persistent or intermittent lameness, particularly if the problem is not immediately addressed (2, 3) (Fig. 4, 5, 6). In the author's experience, particular care should be taken when contouring bone plates with angle-stable screw fixation, as this may direct the screw proximally into the joint. Postoperative radiographs should be carefully evaluated and if a screw is suspected to be within the joint, the patient should be immediately returned to surgery to have the screw redirected or a shorter screw placed (Fig. 5). Broken drill bits and Kirschner wires that do not violate the joint space typically do not prove to be problematical, and there- fore do not need to be retrieved (3). A small number of anti-rotational Kirschner wires that are left in place are reported to loosen over time and subsequently require an additional surgery to remove the implant (5, 7).
Implants may fail postoperatively by bending, breaking, or loosening. Limb alignment and the degree of osteotomy healing should be carefully assessed at the time of diagnosis as not all implant failures necessitate re-operation (4, 18). Aside from implant failure, indications for removal include implant-associated infection, local inflammation, and elective removal during subsequent treatment of meniscal tears or contralateral TPLO (7, 21). Implants are reportedly removed after 2.7–4.8% of TPLO procedures (7, 21).

Persistent stifle instability

Continued instability in the stifle after TPLO may be a source of intermittent or persistent lameness. Insufficient rotation of the tibial plateau segment during TPLO may result in inadequate neutralization of cranial tibial thrust (8). Centring the cylin- drical osteotomy on the intercondylar eminences will produce the most accurate plateau rotation (61). Difficulty performing the desired rotation may occur if there is synostosis between the tibia and fibula (55). In such cases, the authors have found that performing a proximal fibular osteotomy or ostectomy may be necessary to achieve adequate tibial plateau rotation.

A significant increase in tibial plateau angle may occur postoperatively (51, 55, 62). The phenomenon of implant or fixation failure leading to a significantly in- creased tibial plateau angle has been termed 'rock back' of the plateau (51, 55, 62) (Fig. 2). The cause of this complication has not been rigorously investigated. It has been postulated that it may be due to inadequate stabilization of the proximal plateau segment, improper osteotomy positioning, or a modulus mismatch between a rigid implant construct and relatively soft metaphyseal bone (63). If instability of the stifle and lameness result from resultant in- crease in the tibial plateau angle, additional

stabilization of the stifle may be required to improve comfort and function in the patient.
'Pivot shift' may occur after TPLO due to uncontrolled internal rotation of the tibia during the stance phase of the gait. The cause of this complication has not been fully investigated, however, it has been hypothesized to be due to tibial torsion, angular deformity, excessive internal rotation of the tibia, or a combination of these (5, 28, 63). One recent retrospective study of 476 TPLO procedures identified the incidence of 'pivot shift' to be 3.2% (5). Dogs that had a medial menisectomy at the time of TPLO were at higher risk for developing 'pivot shift'. It is possible that this finding may highlight the importance of the intact meniscus in stifle stability. Secondary muscle stabilizers of the stifle joint may play an important role in resolution of this complication, as the obvious gait abnormality re- solved in some of the reported cases (5). More investigation into this complication is needed.

Prevention of complications and outcome of TPLO

Proposed risk factors for increased complication rates include complete preoperative rupture of the CCL, performing a para- patellar arthrotomy, increased patient age and body weight, the Rottweiler breed, single-session bilateral TPLO surgical procedures, absence of jig use, high preoperative tibial plateau angle, medial meniscectomy, osteotomy position, thin craniocaudal crest width and surgeon inexperience (2, 5, 7, 50, 51, 54, 55). Certainly, the surgeon has control over some of these factors and not others. While some complications appear to be primarily due to technical errors in surgical technique, the underlying cause of other complications (such as 'rock back' and 'pivot shift') is less clear.
Knowledge gained through clinical observation and original research has allowed identification of many risk factors and sub- sequent modification of implants and surgical technique. Both of these factors may directly and indirectly affect the complication rate of TPLO (2–8, 18). The improvement in technique and implants, combined with increasing experience of the individual surgeon may be largely responsible for the decrease in TPLO complications over time. The most recently re- ported retrospective studies cite overall complication rates of 9.7% and 14.8%, which is half that of earlier reports (20.6% –28%)(2,3,5,7).
Other factors that may have affected the apparent complication rates in previous studies include the experience level of the surgeon, the surgeon's operating technique and supporting staff, the type of implants used, the regional population and breeds of dogs included in the study, the definition of a complication that was used, and duration of follow-up for the study. Thus, the absence of a reported complication does not necessarily mean that it did not exist. It is unlikely that even the best-designed studies are able to identify every single complication that occurred. The sample size of the previously reported studies was not uni- form, and some complication rates may be skewed due to a relatively high or relatively low population size in the study or the experience of the surgeon. Retrospective studies are often limited to information recorded in the medical records, and are therefore subject to recording omissions or errors. The studies reported in this review had variable follow-up, few were controlled studies, and most provided level IV evidence. Adopting a uniform method of assessing and reporting complications and outcomes of surgical procedures may pro- vide a better assessment of the TPLO

procedure and other surgical procedures used to treat CCL disease in the dog (64–65).Despite the frequency of complications associated with TPLO, only two to six per- cent of standard TPLO procedures require a revision surgery (5, 7). Most complications appear to be satisfactorily address- ed, as owners and surgeons report that dogs have a good to excellent outcome when complications are identified early and properly treated (2– 5, 7, 17). Client edu- cation and communication in the preoperative and postoperative periods is imperative in order for complications to be identified early and addressed by the surgeon immediately. Although the precise cause of, and risk factors for, some complications re- main unclear, it seems reasonable to conclude that, based on the best available evi- dence, complications of TPLO can be reduced with increased surgeon experience, careful surgical planning and accurate execution of the surgical procedure. Identification of known or suspected risk factors and intra-operative technical errors allow subsequent action to be taken to decrease postoperative morbidity. Continued critical evaluation, consistent data reporting, and development of technique or implant modifications may continue to reduce the complication rate and improve outcomes after TPLO surgery.

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Conflict of interest

None declared.

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Table 1

Summary of intraoperative complications which occured during tibial plateau levelling osteotomy (TPLO) procedures in dogs. The largest prospective and retrospective studies reporting on more than one complication are represented.

	Stauffer et al. (4)	Pacchiana et al. (2)	Priddy et al. (3)
Number of TPLO performed:	**696**	**397**	**253**
Tibial fracture	1 (0.1%)	3 (0.8%)	3 (1.2%)
Fibular fracture	1 (0.1%)		6 (2.4%)
Significant haemorrhage	4 (0.6%)	1 (0.3%)	2 (0.8%)
Broken drill bit			7 (2.8%)
Broken screw	1 (0.1%)		
Broken holding pin			1 (0.4%)
Screw in joint		2 (0.5%)	2 (0.8%)
Jig pin in joint			1 (0.4%)
Screw placed in osteotomy			1 (0.4%)
Gauze left in wound			1 (0.4%)

Table 2 Summary of postoperative complications reported after standard tibial plateau levelling osteotomy (TPLO) surgery in dogs. The largest prospective and retrospective studies reporting on more than one complication are represented.

	Fitzpatrick, Solano (7)	Stauffer et al. (4)	Gatineau et al. (5)	Pacchianna et al. (2)	Priddy et al. (3)	Duerr et al. (52)	Conkling et al. (18)	Carey et al. (43)	Cook et al. (13)	Corr, Brown (14)
Number of TPLO performed:	**1146**	**696**	**476**	**397**	**253**	**146**	**118**	**94**	**23**	**21**
Infection	66 (5.8%)		14 (2.9%)	3 (0.8%)	9 (3.6%)		1 (0.8%)		1 (4.3%)	3 (14.3%)
Seroma	8 (0.7%)			13 (3.3%)			1 (0.8%)		3 (13.0%)	
Meniscal tear	28 (2.4%)		10 (2.1%)	4 (1.0%)		1 (0.7%)		2 (2.1%)	1 (4.3%)	
Patellar tendonitis	3 (0.3%)	19 (2.7%)		2 (0.5%)			1 (0.8%)	24 (25.5%)	1 (4.3%)	
Incisional oedema / haematoma / bruising		50 (7.2%)		17 (4.3%)		1 (0.7%)			1 (4.3%)	1 (4.8%)
Traumatic wound dehiscence		13 (1.9%)		7 (1.8%)		2 (1.4%)	3 (2.5%)			
Draining tract				1 (0.3%)	1 (0.4%)					
Bandage complications				14 (3.5%)		1 (0.7%)				
Tibial fracture		3 (0.4%)	1 (0.2%)			1 (0.7%)			2 (8.6%)	1 (4.8%)
Tibial tuberosity fracture	5 (0.4%)	28 (4.0%)		14 (3.5%)	6 (2.4%)	7 (4.8%)	2 (1.7%)	4 (4.3%)		
Fibular fracture	1 (0.09%)	3 (0.4%)	2 (0.4%)	1 (0.3%)	3 (1.3%)	4 (2.7%)	1 (0.8%)			1 (4.8%)
Patellar fracture	1 (0.09%)		1 (0.2%)	1 (0.3%)				1 (1.1%)		
Osteomyelitis				7 (1.8%)	14 (5.5%)	4 (2.7%)				
Medial patellar luxation	3 (0.3%)		5 (1.1%)							
Internal tibial torsion								12 (12.8%)		
Delayed union	3 (0.3%)						6 (5.1%)			
Ring sequestrum					1 (0.4%)					
Pivot shift	3 (0.3%)		15 (3.2%)				1 (0.8%)			
Broken screw	1 (0.09%)			2 (0.5%)	4 (1.5%)	4 (2.7%)	1 (0.8%)			2 (9.5%)
Screw loosening		6 (0.9%)		4 (1.0%)	2 (0.8%)					
Kirschner wire loosening	2 (0.2%)									
Implant failure - other						4 (2.7%)				

Fig. 1 Craniocaudal and mediolateral radiographs taken immediately postoperative (A) and five months postoperatively (B) in a 2.5-year-old male Labrador Retriever that underwent tibial plateau levelling osteotomy surgery. This dog developed an incisional infection, osteomyelitis, delayed union, and sustained a fibular fracture. The patient was treated with antibiotic therapy and the osteotomy and fracture healed. The bone plate and screws were removed eight months postoperatively (C), and the infection resolved.

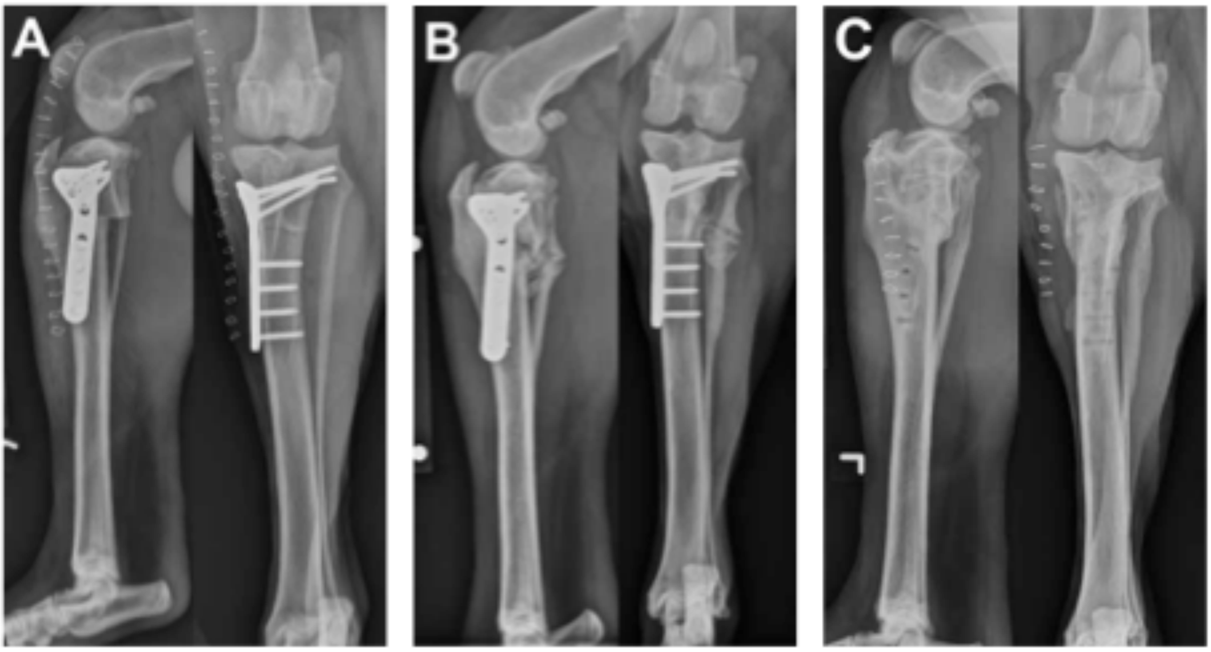

Fig 2: Craniocaudal and mediolateral radiographs taken immediately postoperative **(A)** and at 12 weeks postoperatively **(B)** of a three-year-old female Newfoundland dog that underwent tibial plateau levelling osteotomy surgery. The immediate postoperative radiographs reveal the creation of an oblique osteotomy, lateral translation of the plateau segment, and cranial bone plate placement that may have resulted in the placement of a screw through the osteotomy. The follow-up radiographs reveal a healing tibial tuberosity fracture and fixation failure resulting in ‘rock back’ of the tibial plateau. The immediate postoperative tibial plateau angle was seven degrees and the follow-up tibial plateau angle was 21 degrees.

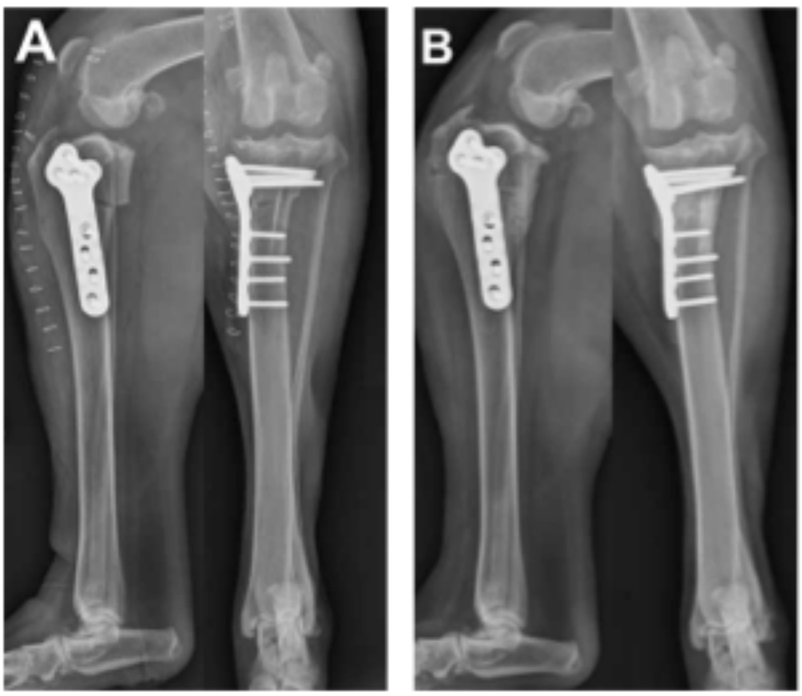

Fig. 3

Craniocaudal and mediolateral radiographs taken immediately postoperative **(A)** of a dog that later sustained a tibial diaphyseal fracture, initiating through the malpositioned distal jig hole **(B)**. Initial stabilization of the fracture was performed with an external skeletal fixator **(C)**. Revision of this repair was performed with internal bone plate fixation and the frac- ture successfully healed **(D)**.

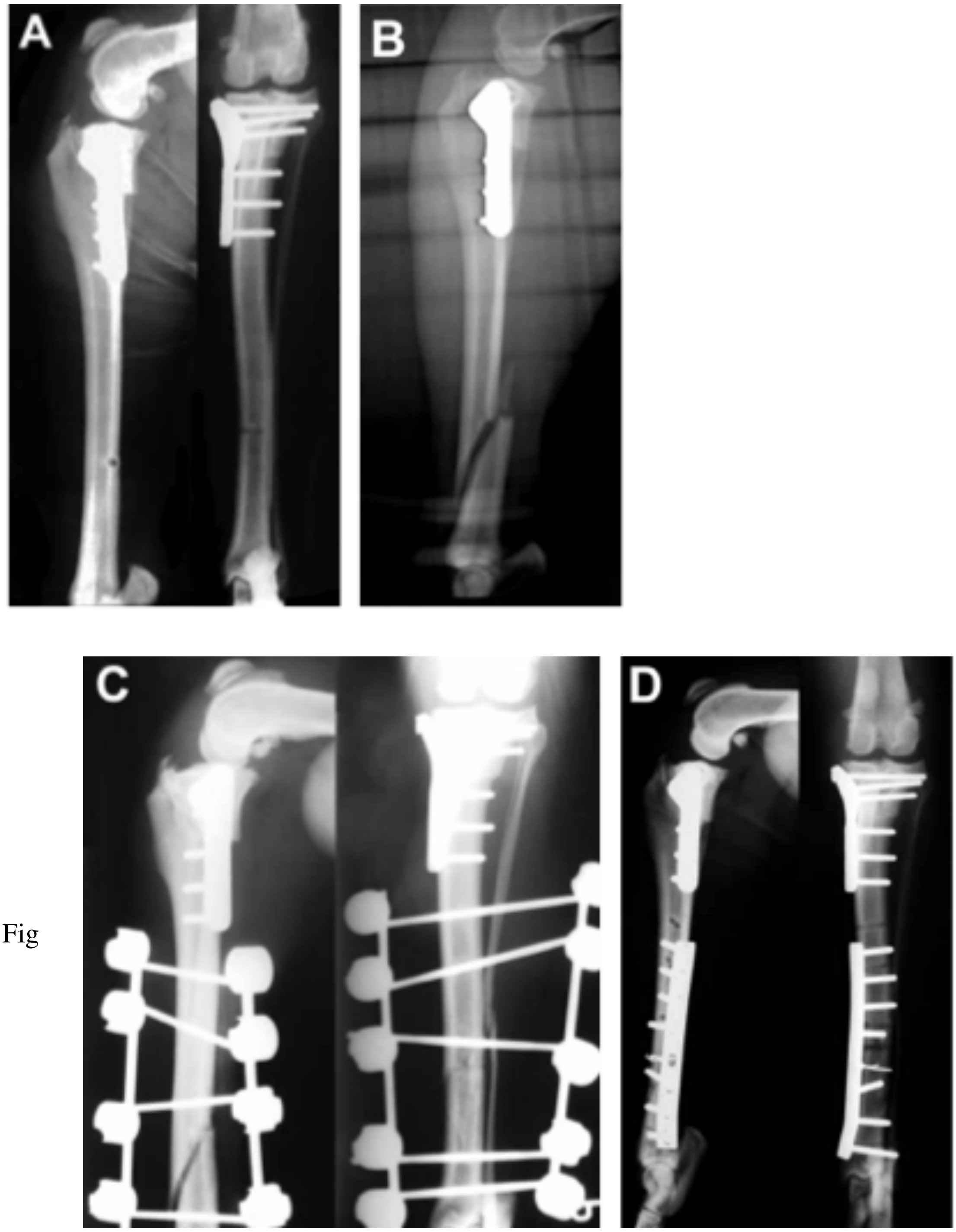

Fig 4: Intra-operative

craniocaudal radiograph of a three-year-old male Boxer dog. The tip of the proximal jig pin is seen penetrating the articular surface of the tibial plateau.

Fig. 5

Craniocaudal and mediolateral radiographs taken immediately postoperative **(A)** that reveal that the most proximal bone screw had been cross-threaded, misdirected, and had entered the joint. The patient was immediately returned to the operating room and the intra-articular screw was replaced with a shorter screw **(B)**.

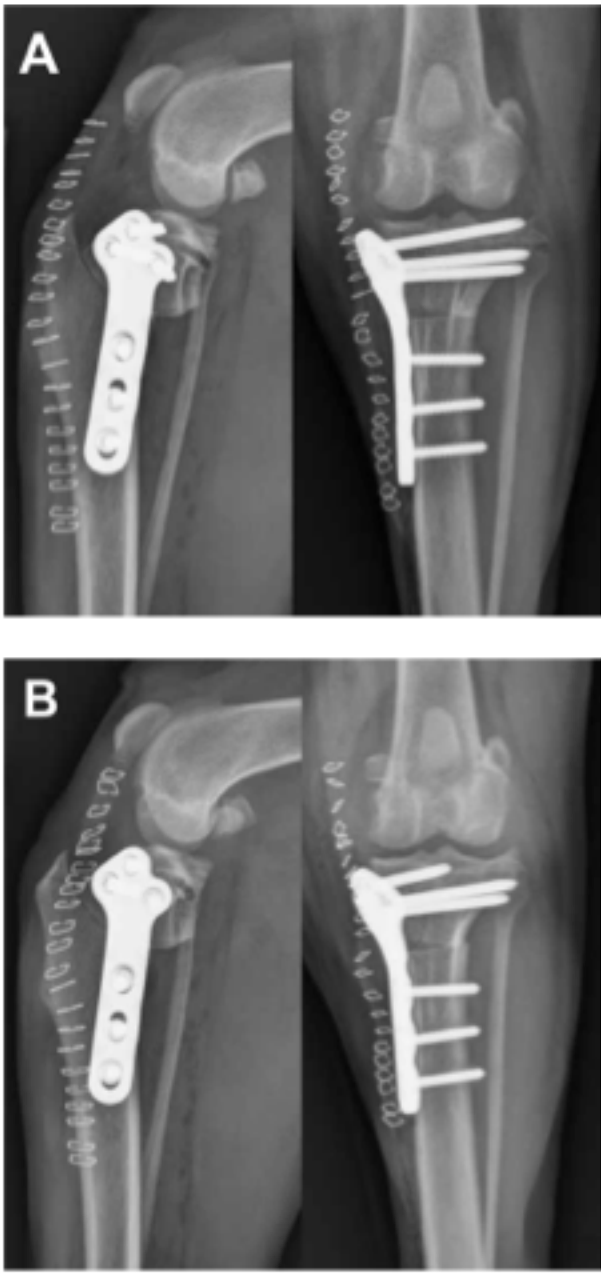

Fig 6: Immediate postoperative mediolateral radiograph of a dog that shows the presence of a broken Kirschner wire that is positioned within the joint space (arrow).