Article published online: 2023-08-29

Unilateral Repair of an Avulsion Fracture of the Caudal Cruciate Ligament Origin Combined with a Ruptured Cranial Cruciate Ligament in a Dog

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VCOT Open 2023;6:e102–e106.

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Abstract

Caudal cruciate ligament (CaCL) femoral avulsion fractures are rarely documented, and a true incidence is unclear. A literature search revealed very few cases of a CaCL avulsion fracture or rupture combined with a cranial cruciate ligament (CrCL) rupture. Only a single case report described surgical treatment of this combination by fragment removal and stifle stabilization with an extracapsular suture. A 1-year-old female spayed Labrador Retriever presented with a hindlimb lameness. Examination revealed cranial drawer of the stifle, consistent with CrCL rupture. Stifle effusion, as well as a bone opacity seen in the trochlear groove, was evident on radiographs. At surgery, arthrotomy revealed a torn CrCL as well as an avulsion fracture of the CaCL origin from the medial femoral condyle. The avulsion fracture was reduced, and three 0.035-inch Kirschner's wires (K-wires) were placed in a divergent fashion through the fragment into the medial femoral condyle. A tibial plateau leveling osteotomy (TPLO) was then performed. Six-week recheck radiographs showed good healing of the TPLO as well as the repaired avulsion fracture, despite breakage of one of the K-wires. The dog was mildly lame at the 6-week follow-up and subsequently improved to clinically normal on the limb at 8-month follow-up with optimal bone healing on radiographs. To the authors' knowledge, this is the first case report to describe a CaCL avulsion fracture repair with K-wires combined with a TPLO for a torn CrCL, with an excellent clinical outcome.

Keywords
- TPLO
- fracture fixation
- traumatic cruciate disease

Introduction

The caudal cruciate ligament (CaCL) originates on the medial femoral condyle at its lateral surface and inserts on the medial edge of the popliteal notch of the tibia.[1] It is the primary restraint against caudal tibial translation (caudal drawer), limits internal rotation of the tibia, hyperextension, and varus and valgus angulation in flexion. CaCL femoral avulsion fractures are rarely documented, and a true incidence is unclear.[2] After a tibial plateau leveling osteotomy (TPLO), which is the standard repair for a cranial cruciate ligament (CrCL) rupture, there is an increase in caudal tibial motion, making the CaCL a more important stabilizer of the stifle postoperatively.[3] Several cases of CaCL avulsion fracture in combination with a torn CrCL have been reported.[4,5] However, to the authors' knowledge, this is the first report describing a CaCL avulsion fracture repair with Kirschner's wires (K-wires) combined with a TPLO for stifle stabilization.

received
November 2, 2022
accepted after revision
May 12, 2023

DOI https://doi.org/10.1055/s-0043-1771232.
ISSN 2625-2325.

Case History

A 1-year-old female spayed Labrador Retriever that weighed 29 kg presented for evaluation of recurrent right hindlimb lameness. Six months prior to presentation, she ran into a fence and presented to the primary care veterinarian for lameness of the right hindlimb. The initial lameness resolved with conservative management with anti-inflammatory therapy but recurred 1 month prior to presentation. At that time, stifle radiographs showed mild right stifle effusion. The patient was then referred for a surgical consult for a suspected torn CrCL.

On presentation, the dog had a grade 1 out of 4 right hindlimb lameness[6] with a history of sporadic non-weight-bearing lameness at home for the past month. Positive cranial drawer, stifle effusion, and discomfort on extension were noted in the right stifle, consistent with a torn CrCL. Neither posterior sag nor caudal drawer and hyperextension were noted; however, these may have been present but not recognized. Stifle radiographs showed mild right stifle effusion, cranial displacement of the infrapatellar fat pad, osteophytes and enthesophyte formation consistent with stifle instability, and a preoperative tibial plateau angle (TPA) of 25 degrees. In retrospect, a mineral opacity was seen in the trochlear groove, indicative of the avulsion fracture of the CaCL (►Fig. 1).

A standard medial parapatellar arthrotomy was performed and confirmed a complete CrCL tear. An avulsion fracture of the CaCL at its origin on the medial femoral condyle was identified (►Fig. 2). Capsular fibrosis was noted and was consistent with cruciate disease. The CrCL was debrided and a caudal meniscal release[1] was performed on the intact medial meniscus to prevent poststabilization meniscal injury. The avulsed fracture fragment (1cm × 1.6 cm) was reduced using AO reduction forceps, and three 0.035-inch K-wires were placed in a divergent fashion intra-articularly through the fragment into the medial femoral condyle. A TPLO was then performed in a routine fashion and stabilized with a 3.5-mm New Generation Device (NGD) plate.[1]

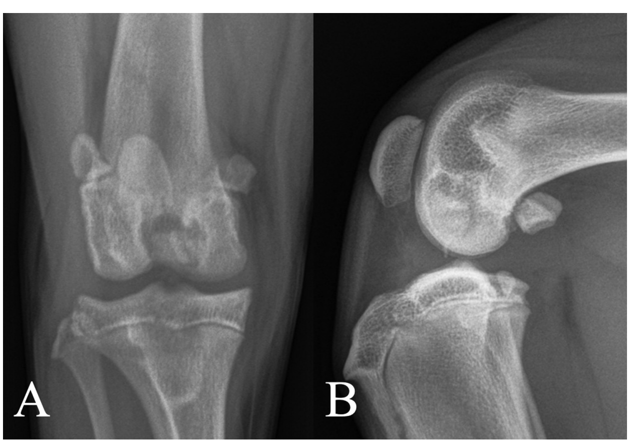

Fig. 1 (A) Caudocranial and (B) mediolateral radiographic projections of the right stifle. There was increased soft-tissue opacity in the cranial joint space and compression of the infrapatellar fat pad. Osteophytes on the distal edge of the patella, fabella, and caudal to the tibial plateau and enthesophytes at the tibial attachment site of the cranial cruciate ligament and attachment site of the long digital extensor muscle groove were present. Subchondral sclerosis of the trochlear groove and tibial plateau was identified. There was a nondisplaced avulsion fracture of the lateral aspect of the medial femoral condyle.

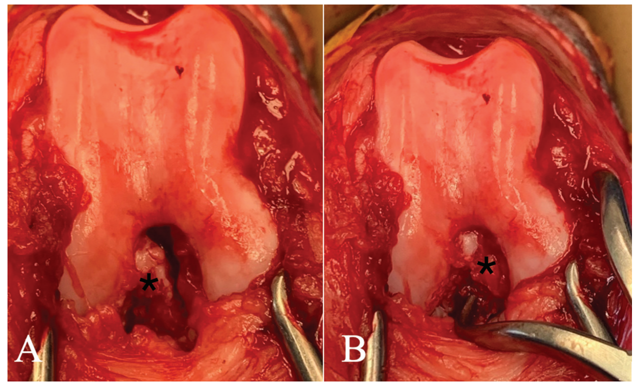

Fig. 2 Arthrotomy of the right stifle joint showing the avulsion fracture of the femoral attachment of the caudal cruciate ligament (A) before reduction and (B) after reduction using point to point reduction forceps. Asterisk symbols (*) indicate the avulsion fracture fragment in the medial trochlear ridge.

The stifle had normal range of motion postoperatively and radiographs showed good alignment of the tibia and femur, a postoperative TPA of 7 degrees, and good reduction and apposition of the avulsed fracture fragment (►Fig. 3). Two weeks after surgery, the dog was mildly lame in the right hindlimb. At 6 weeks, the dog had improved at home but had a mild persistent lameness. Recheck right stifle radiographs showed good healing of the TPLO and the avulsion fracture fragment, despite breakage of the most distal/caudal K-wire (►Fig. 4). There was no pain reaction on palpation in the area of the broken K-wire. At 8-month recheck, the patient had no detectable lameness in the surgical limb. The stifle was stable and comfortable on palpation. Radiographs showed optimal healing of the tibia and femur (►Fig. 5).

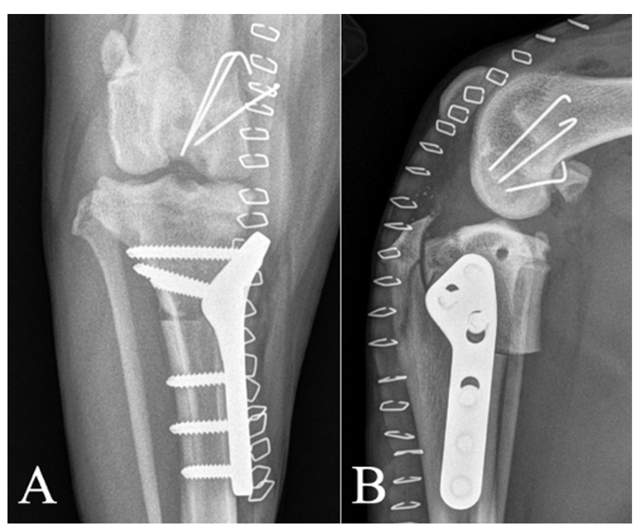

Fig. 3 (A) Caudocranial and (B) mediolateral radiographic projections of the right stifle immediately postsurgery.

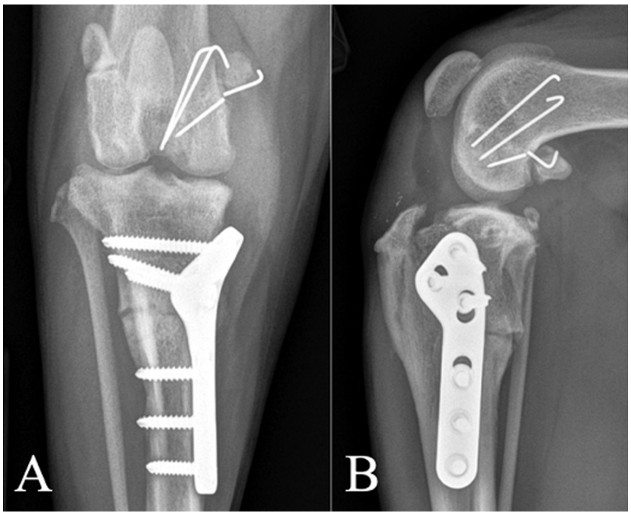

Fig. 4 (**A**) Caudocranial and (**B**) mediolateral radiographic projections of the right stifle 6 weeks postsurgery. There was moderate new bone formation at the tibial plateau leveling osteotomy site. The most distal and medial K-wire was broken. The femoral avulsion fracture healed with no visible fracture gap.

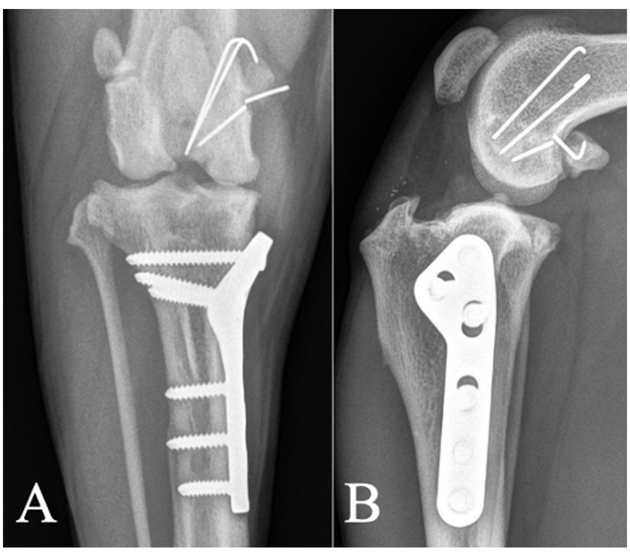

Fig. 5 (**A**) Caudocranial and (**B**) mediolateral radiographic projections of the right stifle 8 months postsurgery. There is no visible fracture gap at the femoral avulsion site nor at the tibial plateau leveling osteotomy site. The implants remain stable compared with most recent radiographs.

Discussion

There is a lack of literature describing surgical treatment for combined CaCL avulsion fracture and CrCL rupture in the dog. A literature search revealed very few cases of this combination[1,7,8] and only a single case report in a dog[4] of surgical treatment by fragment removal and stifle stabilization with an extracapsular suture. To the authors' knowledge, this is the first case report describing the successful surgical treatment of CaCL femoral avulsion fracture with K-wires along with a TPLO for stifle stabilization secondary to a torn CrCL.

In human medicine, advanced imaging is used in addition to drawer tests for the diagnosis of cruciate disease. Magnetic resonance imaging (MRI) can be used to confirm cruciate ligament injury and to evaluate for other injuries in the knee including avulsion fractures.[8] On radiography, a posterior cruciate ligament (PCL) avulsion fracture is diagnosed when there is focal discontinuity of the PCL facet at the posterior aspect of the tibia.[9] If radiographs cannot confirm suspected avulsion fracture, an MRI is recommended. Computed tomography (CT) is also used to assess the size and comminution of the fracture fragments for preoperative planning. Conservative treatment of PCL tears and nondisplaced avulsion fractures has good patient outcomes.[10] Indications for surgical treatment include an avulsion fracture with large bony fragments, presence of multiple ligament injuries, and symptomatic posterior knee instability.[11] Surgical treatment involves arthroscopic ligament reconstruction and internal fracture fixation.[12]

In veterinary medicine, a CaCL rupture is diagnosed when there is increased caudal instability in flexion and depression of the tibial tuberosity relative to the patella (posterior sag).[13] However, it can be difficult to distinguish between cranial and caudal drawer. Neither posterior sag nor hyperextension was noted on examination. However, it can be challenging to isolate these signs of instability with cranial drawer present. Radiographs are typically used to assess femoral and tibial torsion and to rule out concurrent injuries for preoperative planning.[14] Joint effusion may be the only radiographic change for a CaCL tear but is nonspecific since it is expected in a CrCL tear as well. Multiple mineral opacities superimposed on the femoral condyle were suggestive of a CaCL avulsion fracture in two case reports.[2,4] Diagnosis was confirmed via a lateral arthrotomy. Compared with the CrCL, the CaCL is more resistant to rupture but is predisposed to avulsion fractures.[15] Radiographs are an important diagnostic test to perform when a CaCL injury is suspected. However, CT is better at diagnosing avulsion fractures when compared with radiography and MRI.[7] MRI is rarely used for the diagnosis of cruciate ligament rupture in dogs due to high cost, limited availability, need for general anesthesia, and minimal additional information provided compared with radiography. CT could be considered but has similar limitations to MRI. Arthroscopy and arthrotomy are diagnostic for cruciate ligament ruptures.

In our case, positive cranial drawer and radiographic stifle changes were suggestive of a CrCL rupture. The CaCL avulsion fracture was not initially diagnosed on radiographs and was identified after arthrotomy and joint examination. In retrospect, mineral opacity was seen in the trochlear groove, indicative of the avulsion fracture of the CaCL in this case. Additional imaging modalities, such as a CT scan, may have been considered in this case if the fracture was initially identified on radiographs, but would unlikely have changed the surgical treatment.

Reported treatments of CaCL avulsion fracture in dogs include conservative treatment without surgery,[7] removal of the avulsion fracture fragment,[4] ligament reconstruction through femoral bone tunnels,[16] and fracture stabilization with lag screws.[17,18] Conservative treatment of CaCL rupture in dogs is reasonable if there is a lack of clinical signs and evidence of osteoarthritis.[13] Experimental transection of the CaCL failed to show evidence of osteoarthritis 6 months postsurgery.[19] However, when a CaCL tear is accompanied by another ligamentous injury, surgical stabilization is recommended.[15] In this case, conservative treatment was not considered due to concurrent CrCL tear and a CaCL avulsion fracture.

Failure to stabilize a CaCL avulsion fracture may contribute to persistent stifle instability despite surgical stabilization with TPLO. The TPLO was designed to address CrCL rupture specifically by decreasing cranial tibial thrust and preventing cranial tibial translation. After TPLO, there is a linear increase in caudal tibial thrust due to increased axial tibial load.[3] There is altered stifle biomechanics following TPLO that may predispose or worsen CaCL injury due to increased caudal tibial motion. CaCL avulsion fracture fixation can help provide optimal outcome of the TPLO and reduce osteoarthritis formation in the stifle.[20] In this case, the decision to perform a TPLO after recognition of the avulsion fracture was made due to the size and age of the dog, along with the good stabilization that was achieved of the avulsion fracture fragment. The intended rotation of the tibial plateau segment was unchanged after diagnosing the avulsion fracture in surgery. Decreasing the amount of rotation to limit the increase in caudal tibial thrust to protect the CaCL could have been considered but could have led to a persistent cranial tibial thrust.

Fortunately, the avulsion fracture fragment was moderately sized (1 cm × 1.6 cm) and was amenable to K-wire stabilization. K-wires provide excellent fixator stability[18] and can be countersunk to avoid damage to the articular cartilage.[21] With their smaller size, the risk of fracture was reduced and they were easier to place during a medial arthrotomy to the stifle. If fragments are too small to allow for implants, they can be stabilized with monofilament absorbable suture through parallel bone tunnels as described by Bourbos and colleagues.[16] Alternatively, a lag screw may be used for fracture repair but may cause more trauma to the articular cartilage due to its larger size and have a higher risk of fragment fracture.

This patient suffered a CrCL rupture and a CaCL femoral avulsion fracture, but the chronological order is unclear. Avulsion fractures of the cruciate ligament attachment are common in young growing dogs and most often seen at the tibial attachment of the CrCL. The history of the traumatic event (running into a fence) 6 months prior to presentation could have been the inciting event for these injuries. However, the lameness had clinically resolved up until 1 month prior to presentation. When the lameness recurred, there was no report of additional trauma, so it is unclear if a previous traumatic injury was exacerbated or this reflected a new injury. The avulsion fracture fragment, in this case, was easily reduced with no callus or evidence of remodeling indicating a recent fracture. The meniscus was intact and excessive chronic pathology was not present, also consistent with a recent CrCL rupture. CaCL injuries usually require excessive, caudally directed force to the proximal aspect of the tibia and hyperextension of the stifle, and are exclusively traumatic.[13] Furthermore, it is rare for a CrCL to be degenerative in an animal younger than 1 year. Therefore, in this case, we suspect perhaps a nondisplaced fracture of the CaCL origin occurred at the time of the original trauma with a more recent displacement of the fracture fragment along with a rupture of the CrCL leading to the more acute lameness.

External coaptation such as a splint can be used for stabilization of minimally displaced avulsion fractures. External coaptation was not used in this case as internal fracture fixation using three K-wires was presumably adequate to resist fracture forces. In addition, limb immobilization after TPLO is contraindicated since it prevents stifle joint flexion and extension.[22] Early physiotherapy is recommended to prevent muscle atrophy and to build muscle mass and strength, which would be prevented by external coaptation.

At the 6-week recheck, radiographs showed one of the K-wires broke. Implant breakage may have been due to fatigue failure.[23] The gastrocnemius muscle originates from the lateral and medial supracondylar tuberosities and may have prevented cutting the most caudal K-wire closer to the bone.[1] There is also significant movement of the muscles caudally with flexion and extension of the stifle affecting that pin more than the others. The repeated movement and cyclic stress likely caused breakage. The other two K-wires remained intact and provided stability for the fracture to heal appropriately. The patient recovered with no complications, and there was minimal lameness at rechecks as expected during TPLO recovery. At the 8-month recheck, the patient had no detectable lameness in the surgical limb. Radiographs showed optimal healing of the tibia and femur (►**Fig. 5**).

In conclusion, to the authors' knowledge, this is the first report describing a CaCL avulsion fracture repair with K-wires combined with a TPLO for stifle stabilization for a CrCL with a good clinical outcome. The main limitations of this manuscript are its retrospective nature and that this is a single case report. Further investigation is needed to determine the change in biomechanics when doing a TPLO in combination with a femoral avulsion fracture repair. A study with a larger sample size or a study of prospective nature may be beneficial. Direct comparison of different avulsion fracture repair techniques cannot be done due to the scarcity of case reports with a combined CaCL avulsion fracture and CrCL tears, and none with combined TPLO and fracture stabilization. However, CaCL femoral avulsion fractures should be repaired to maintain the primary stabilizer function against caudal tibial translation, especially if concurrent instability due to CrCL will be stabilized with a TPLO to resist the increased caudal tibial motion.

Funding
None.

Conflict of Interest
None declared.

References

1 Johnston SA, Tobias KM. Stifle joint. In: Veterinary Surgery: Small Animal. St. Louis, MO: Elsevier; 2018:1071–1168
2 Soderstrom MJ, Rochat MC, Drost WTOD. Radiographic diagnosis: avulsion fracture of the caudal cruciate ligament. Vet Radiol Ultrasound 1998;39(06):536–538
3 Reif U, Hulse DA, Hauptman JG. Effect of tibial plateau leveling on stability of the canine cranial cruciate-deficient stifle joint: an in vitro study. Vet Surg 2002;31(02):147–154
4 Krystalli AA, Prassinos NN, Mantis P. Caudal cruciate ligament avulsion at its origin in a dog. J Hell Vet Med Soc 2019;70(03): 1733
5 Johnson AL, Olmstead ML. Caudal cruciate ligament rupture. A retrospective analysis of 14 dogs. Vet Surg 1987;16(03):202–206
6 Theresa MW, Kyle WM, Colleen GD, Angela JM, Felix MD. Evaluation of pacing as an indicator of musculoskeletal pathology in dogs. J Vet Med Anim Health 2016;8(12):207–213
7 Monotti IC, Davies SE, Lidbetter DA. What is your diagnosis? Caudal cruciate avulsion fracture. J Am Vet Med Assoc 2015; 246(05):507–509
8 Katsman A, Strauss EJ, Campbell KA, Alaia MJ. Posterior cruciate ligament avulsion fractures. Curr Rev Musculoskelet Med 2018;11 (03):503–509
9 Servant CTJ, Ramos JP, Thomas NP. The accuracy of magnetic resonance imaging in diagnosing chronic posterior cruciate ligament injury. Knee 2004;11(04):265–270
10 Kocher MS, Shore B, Nasreddine AY, Heyworth BE. Treatment of posterior cruciate ligament injuries in pediatric and adolescent patients. J Pediatr Orthop 2012;32(06):553–560
11 Veltri DM, Deng X-H, Torzilli PA, Warren RF, Maynard MJ. The role of the cruciate and posterolateral ligaments in stability of the knee. A biomechanical study. Am J Sports Med 1995;23(04): 436–443
12 Accadbled F, Knörr J, Sales de Gauzy J. All inside transtibial arthroscopic posterior cruciate ligament reconstruction in skeletally immature: surgical technique and a case report. Orthop Traumatol Surg Res 2013;99(03):361–365
13 Harari J. Caudal cruciate ligament injury. Vet Clin North Am Small Anim Pract 1993;23(04):821–829
14 Jerram RM, Walker AM. Cranial cruciate ligament injury in the dog: pathophysiology, diagnosis and treatment. N Z Vet J 2003;51 (04):149–158
15 Decamp CE, Johnston SA, Dejardin LM. The stifle joint. In: Brinker, Piermattei and Flo's Handbook of Small Animal Orthopedics and Fracture Repair. St Louis, MO: Elsevier Health Sciences; 2015: 597–669
16 Bourbos A, Cinti F, Baroni M, Piola V, Pisani G. Long-term outcome of a combined surgical approach for repair of femoral avulsion fracture of the caudal cruciate ligament in a dog. Vet Rec Case Rep 2020;8(02):
17 Wong WT. Caudal cruciate ligament avulsion fracture in a dog. Aust Vet J 1994;71(03):82–83
18 Plaga BR, Royster RM, Donigian AM, Wright GB, Caskey PM. Fixation of osteochondral fractures in rabbit knees. A comparison of Kirschner wires, fibrin sealant, and polydioxanone pins. J Bone Joint Surg Br 1992;74(02):292–296
19 Harari J, Johnson AL, Stein LE, Kneller SK, Pijanowski G. Evaluation of experimental transection and partial excision of the caudal cruciate ligament in dogs. Vet Surg 1987;16(02):151–154
20 Frost-Christensen LN, Mastbergen SC, Vianen ME, et al. Degeneration, inflammation, regeneration, and pain/disability in dogs following destabilization or articular cartilage grooving of the stifle joint. Osteoarthritis Cartilage 2008;16(11):1327–1335
21 Guerrero TG, Koch D, Montavon PM. Fixation of a proximal femoral physeal fracture in a dog using a ventral approach and two Kirschner wires. Vet Comp Orthop Traumatol 2005;18(02): 110–114
22 Monk ML, Preston CA, McGowan CM. Effects of early intensive postoperative physiotherapy on limb function after tibial plateau leveling osteotomy in dogs with deficiency of the cranial cruciate ligament. Am J Vet Res 2006;67(03):529–536
23 Sharma AK, Kumar A, Joshi GR, John JT. Retrospective study of implant failure in orthopaedic surgery. Med J Armed Forces India 2006;62(01):70–72