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Tibial Diaphyseal Fracture Rates Following Tibial Tuberosity Advancement Rapid (TTAR) and Traditional Tibial Tuberosity Advancement (tTTA)

A Knowledge Summary by

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KNOWLEDGE SUMMARY

PICO question

In dogs with cruciate disease, is the use of TTA Rapid (TTAR) compared to traditional TTA (tTTA) associated with a higher risk of tibial diaphyseal fractures?

Clinical bottom line

Based on studies published between January 2013 and January 2018, the rate of tibial diaphyseal fractures as a complication of Tibial Tuberosity Advancement Rapid (TTAR) surgery is within the published limits of traditional Tibial Tuberosity Advancement (tTTA). In this period, seven studies were related to tTTA, comprising of four; one case series, two retrospective case-control studies, and one retrospective cohort study. Five case series were related to TTAR. All evidence within this period has been observational (Level 3 and 4 evidence). No direct head-to-head comparison between the techniques has been studied.

The evidence

Based on a literature search of the last 5 years (prior to 23 January 2018), there were seven PICO related studies for tTTA and five for TTAR. Of the articles for tTTA, 3/7 were retrospective case series, 1/7 prospective case series, 2/7 retrospective case-controls and 1/7 retrospective cohort study. All TTAR studies were case series.

Technique	Evidence
tTTA	Level 4 – four studies Level 3 – three studies
TTAR	Level 4 – five studies

Table 1: A summary of the strength of evidence.

Summary of the evidence

Costa et al., (2017) tTTA	
Population:	Dogs
Sample size:	1613
Intervention details:	• All dogs received perioperative Cephazolin 22 mg/kg. • All dogs received traditional TTA procedure (KYON or Medicatech Vet).

	• Meniscal release or meniscectomy was performed based on preference. • No bone grafts were placed on osteotomy site. • All patients received postoperative coaptation.
Study design:	Retrospective case-control study
Outcome studied:	Major complication rates in dogs receiving tibial tuberosity advancement surgery and the effects of medial meniscal release on postoperative meniscal tear.
Main findings: (relevant to PICO question):	**Major complication rate – 13.4%** Minor complications – not included **Medial meniscal tear** 40.5% had medial meniscal injury and were treated with partial meniscectomy 59.4% had normal meniscus. 72.4% of these dogs had meniscal release. 0.5% of these dogs developed postliminary meniscal injury. 27.6% of dogs with normal meniscus did not receive meniscal release. 10.2% developed postliminary meniscal injury. **Postoperative patellar luxation** 1.2% developed patellar luxation postoperatively. **Surgical site infection** 6.9% of dogs developed superficial surgical site infection All were managed successfully with conservative treatment. 1.1% developed deep SSI necessitating surgical intervention. **Implant failure and fractures** 1% of dogs had implant failure requiring revision surgery. 0.7% (11 dogs) developed fracture; 3/11 tibial diaphyseal fractures and 8/11 tibial tuberosity fracture. **PICO –** three (0.18%) tibial diaphyseal fractures were reported.
Limitations:	• This study is retrospective and may be affected by bias in case selection and suitability for TTA. • Factors that could have affected surgical outcome were not assessed, such as limb conformation or body condition score. • Minor complications were not assessed. • Being retrospective in nature, this study confuses the term incidence with prevalence. • Did not correlate the use of perioperative antibiotics and the development of surgical site infection. • There was no power calculation.

Danielson et al., (2016) tTTA	
Population:	Dogs receiving single-session bilateral plated tibial tuberosity advancement.
Sample size:	148 stifle joints
Intervention details:	Single stage bilateral traditional TTA.

	68 tTTAs were performed with forked plates. 75 tTTAs were performed with screw plates.
Study design:	Retrospective case series
Outcome studied:	Short-term radiographic complication rates and healing scores in bilateral single-session TTAs.
Main findings: (relevant to PICO question):	Overall radiographic complication rates of 17.6% (13/72 dogs), of which only one dog was considered to have major complications. Minor complications in 12 dogs include forked plate displacement (6), tibial tuberosity fracture (4), screw failure (2) and cage displacement (1). Forked plates had greater complications compared to screw plates. Four stifle joints had tibial tuberosity fractures. **PICO** – One stifle joint had tibial diaphyseal fractures (0.007%).
Limitations:	• The radiographic complications were evaluated by only one radiologist. • The radiographic scoring system is subjective and may be prone to inter-operator variability. • There is no control population (unilateral TTA) used for comparison and testing of the null hypothesis. • Comparison was based on results of other studies. • The outcomes of patients with major and minor complications were not reported. • Non-radiographic complications were not reported. • Statistical significance (P value) for comparing complications between forked and screw plates was not reported.

Proot & Corr (2013) tTTA	
Population:	122 dogs
Sample size:	167 stifle joints
Intervention details:	• All dogs received plated TTA by the same surgeon. • Dogs with meniscal pathology were partially or completely resected. Dogs with intact meniscus were left in situ. • Consecutive records were plotted retrospectively using cumulation summation technique (CUSUM) to measure cumulative success for clinical audit and competence of a single surgeon over time.
Study design:	Retrospective case series
Outcome studied:	• Cumulative success rates of a single general practitioner surgeon. • Major and minor complication rates.

Main findings: (relevant to PICO question):	**Minor complications in 14/167 (8%)** • Superficial wound infection (8/13) • Minor dehiscence (1/13) • Seroma (4/13) • Acute lameness responding to conservative treatment 3/13) • Septic arthritis not requiring surgery 1/13 **Major complications in 15/167 (9%)** • Septic arthritis requiring surgery 3/15 • Tibial tuberosity fracture 3/13 • Medial patellar luxation 1/15 • Late meniscal injury (6/15) • Major dehiscence (1/15) • Severe patellar desmitis (1/15) Overall success rate is 91% over 167 procedures. 22 procedures were required before the published veterinary surgeon became acceptably competent to perform tTTA and have complications within published ranges. **PICO – 0 dogs had tibial diaphyseal fractures.**
Limitations:	• This paper only measured success as the absence of complication rates, and not the clinical outcome.

de Lima Dantas et al., (2016) tTTA	
Population:	Boxer vs. non-Boxer dogs with cruciate disease
Sample size:	36 Boxer stifle joints and 271 non-Boxer stifle joints
Intervention details:	All dogs received forked plate TTA Meniscus: • 12/36 Boxers and 94/271 non-Boxers had cranial cruciate ligament remnant debrided. • 8/36 Boxers and 91/271 non-Boxers had medial meniscal injury treated with partial meniscectomy. • 2/36 Boxers and 15/271 non-Boxers had complete medial meniscectomy. • 1/36 Boxers and 3/271 non-Boxers had medial meniscal release. • 15/34 Boxer and 111/250 non-Boxer stifle joints received bone graft. Antibiotics: • 11/30 Boxers and 123/264 non-Boxers received amoxicillin-clavulanic acid perioperatively. • 19/30 Boxers and 141/264 non-Boxers received Cefuroxime perioperatively. • 24/36 Boxers and 152/271 non-Boxers received antibiotics postoperatively.

Study design:	Retrospective cohort study
Outcome studied:	Incidence of major and minor complication rates associated with tTTA in Boxers vs. non-Boxers.
Main findings: (relevant to PICO question):	• 14/36 (38.9%) Boxers and 37/271 (13.6%) non-Boxers had major complications (P < 0.001). • 6/36 (16.7%) Boxers and 6/271 (2.21%) non-Boxers had minor complications (P = 0.003). • 4/36 (11.1%) Boxers and 22/271 (8.1%) non-Boxers had late meniscal injury (P = 0.52). • 7/36 (19.4%) Boxers and 11/271 (4.1%) non-Boxers had postoperative infections. • Boxers compared to non-Boxers had an odds ratio of 5.78 of developing complication. • 2/36 (5.6%) Boxers had tibial tuberosity fractures compared to 1/271 (0.4%) non-Boxers (P = 0.03). • **PICO – 0 cases had tibial diaphyseal fractures.**
Limitations:	• Retrospective design predisposes the study population towards bias. • Complication rates were determined based on medical records of a referral hospital – this may have been under- or over-estimated as it does not take into consideration complication rates detected by a referring veterinarian. • This study includes complications by residents as well as specialists, which may influence the incidence due to the learning curve of residents. • Small number of Boxer dogs compared to control population (36 vs. 271). • No randomisation or blinding, which can lead to bias.

Kiefer et al., (2015) tTTA	
Population:	Dogs that underwent single-stage bilateral plated TTA vs. unilateral plated TTA
Sample size:	44 (88) bilateral TTA (bTTA) vs. 86 unilateral TTA (uTTA)
Intervention details:	All dogs received plated TTA system – manufacturer undefined. All dogs received commercial synthetic or cancellous bone graft on osteotomy site. Some dogs received external coaptation (number undefined). All dogs were re-evaluated at: • 10 weeks postoperatively to evaluate skin sutures • 4 and 8 weeks for radiographs.
Study design:	Retrospective case-control
Outcome studied:	Major and minor complication rates of bTTA compared to uTTA at 4 and 8 weeks postoperatively.

	Major complications defined as complications requiring further surgery. Minor complications defined as any other complications.
Main findings: (relevant to PICO question):	**Major complication rates (no significant difference)** bTTA 11/88 (12.5%) vs. uTTA 2/86 (2.3%) **Minor complication rates (significantly different)** bTTA 23/88 (26.1%) vs. uTTA 21/86 (24.4%) **Overall complication rate (no significant difference)** bTTA 31/88(35.2%) vs. uTTA 21/86 (24.4%) **Fracture** bTTA – 2/88 tibial diaphyseal fracture and 9/99 tibial tuberosity fracture uTTA – 1/88 tibial tuberosity fracture **PICO – 2/88 (2.3%) tibial diaphyseal fracture in bTTA and 0/88 in uTTA**
Limitations:	• Retrospective design. • tTTA procedure was modified over time so there could have been more complications in earlier cases. • Postoperative care was not standardised. • Did not compare staged bTTA vs single-stage bTTA. • Relative risks were not reported.

McDonald et al., (2013) tTTA	
Population:	Skeletally mature dogs > 17 kg
Sample size:	24 dogs
Intervention details:	• All dogs underwent arthrotomy or arthroscopy. • No dogs received meniscal release. • Partial meniscectomy performed in cases of meniscal injury. • All dogs received plated Securos Surgical TTA XGEN system. • All dogs received autologous cancellous bone graft into osteotomy space. • All dogs received exercise restriction for 6 weeks.
Study design:	Prospective case series
Outcome studied:	Complications, lameness, thigh circumference, range of motion, radiographic osteoarthritis at 6 weeks, 6 months, and 1 year.
Main findings: (relevant to PICO question):	**Postoperative complications 8/24 (33.3%)** • SSI 2/24 – resolved with antibiotics. • Fracture of tibial tuberosity 1/24. • Recurrent lameness 6/24 dogs – responded to conservative management. **PICO – 0 dogs had tibial diaphyseal fracture.**
Limitations:	• Very small sample size. • Utilised thigh circumference (TC) and range of motion (ROM) as a measure of limb use, as opposed to peak

	vertical forces. • Postoperative rehabilitation was performed on some dogs and not others, which may influence TC and ROM. • Clinical outcomes were subjectively measured using lameness score. • Follow up radiographic signs of osteoarthritis were measured subjectively by one certified radiologist.

Hans et al., (2017) tTTA	
Population:	Large breed dog > 50kg
Sample size:	145 stifle joints
Intervention details:	91 stifle joints received Securos Surgical TTA XGEN plated system 54 stifle joints received Tibial Plateau Leveling Osteotomy (TPLO)
Study design:	Retrospective case-control
Outcome studied:	Major and minor complication rates of TTA compared to TPLO in large breed dogs. The null hypothesis is that there is a difference in major complications between the two techniques, based on medical records.
Main findings: (relevant to PICO question):	**TTA group** **Overall complication –** 33% **Major complication rate 18/91 (19.8%)** • 14/91 surgical site infection • 4/91 tibial tuberosity fracture • 1/91 stifle joint receiving TTA resulted in diaphyseal fracture • 4/91 required implant removal • One case concurrent tibial tuberosity fracture and SSI **Minor complication rate – 13/91 (13.2%)** • Seroma – 7/91 • Minimally displaced tibial tuberosity fracture 3/91 • Remainder – patellar desmitis, incidental implant breakage and incisional dehiscence **PICO – 1/91 (1.1%) cases had tibial diaphyseal fracture** **TPLO group** **Major complications –** 15/54 (27.8%) • 14/54 (25.9%) surgical site infection • 8/54 (14.8%) required implant removal **Minor complication –** 12/54 (22.2%) • 7/54 seroma • 2/54 incisional irritation • 2/54 fibular fracture
Limitations:	• Surgeries were performed either by a specialist or resident. However, a comparison between the two groups was not analysed.

	• The power of the study was not indicated. • Authors did not declare how many dogs were censored and excluded for not meeting the inclusion criteria. • Lack of randomisation. • Reliance on medical record accuracy. • Declared conflict of interest from one of the authors, who receives royalties for Securos Surgical XGEN TTA system.

Butterworth & Kydd (2017) TTAR	
Population:	Dogs with cruciate disease
Sample size:	141 clinically lame dogs, 152 stifle joints
Intervention details:	• All dogs received TTAR surgery. • No dogs received meniscal release. • All but four dogs received nanocrystalline hydroxyapatite paste on osteotomy gap.
Study design:	Case series
Outcome studied:	Subjective evidence of lameness and complications by clinical assessment at 3 months, and validated questionnaire at >6 months postoperatively.
Main findings: (relevant to PICO question):	• Outcome was considered clinically satisfactory in 99% of 135 dogs 3 months postoperatively and 86% of 108 dogs in owner questionnaire. • 44/152 (29%) of stifle joints had medial meniscal injury requiring meniscectomy • 9/108 (8%) developed late meniscal injury • 3/152 (1.97%) stifle joints developed SSI treated adequately with antibiotics • 2/152 (1.3%) developed fracture of the tibial tuberosity • Tibial osteotomy gap healed at a mean and median of 7.94 and 7 weeks. **PICO –** 1/152 (0.66%) developed tibial diaphyseal fracture treated by internal fixation.
Limitations:	• Medium term follow-up was conducted using owner-assessed questionnaire. • Outcome was based on subjective clinical exam. • Number of cage size and number of breeds were reported but not correlated against each other. • No control group for comparison.

Samoy et al., (2015) TTAR	
Population:	Dogs with unilateral cruciate disease

Sample size:	50 dogs
Intervention details:	• All dogs received amoxicillin clavulanic acid 8.75 mg subcutaneously preoperatively. • All dogs received TTAR surgery. • All dogs received meniscal release. • All dogs received hydroxylapatite bone paste onto osteotomy gap. • All dogs had external coaptation for 2–3 days postoperatively. • All dogs received postoperative antibiotics for 5 days.
Study design:	Prospective case series
Outcome studied:	Outcomes, minor and major complication rates.
Main findings: (relevant to PICO question):	• 42% of dogs had medial meniscal injury. • All owners were satisfied with outcome of surgery. • Subjective assessment at 3 months postoperatively showed 28 dogs (56%) had an excellent outcome, 20 dogs (40%) had a good outcome and two dogs (4%) had a moderate outcome (one clinical healing and one complete healing of the osteotomy). • 15/50 (30%) of dogs had undefined minor complication (undefined). • 2/50 (4%) dogs developed tibial tuberosity fracture; only one required surgical revision. • **PICO – 0% of dogs developed tibial diaphyseal fracture**
Limitations:	• Postliminary meniscal injury not reported. • Unclear if SSI did not develop or was unreported. • Small sample size. • Short follow-up times (3 months). • Not tested against a control group. • Not all dogs received surgery with the aid of a saw guide. • Outcome was based on subjective clinical exam only. • Conflict of interest that the developer of the technique is also the primary author.

Dyall & Schmokel (2017) TTAR	
Population:	Small breed dog – mean weight 9 kg (4.8–15 kg)
Sample size:	48 stifle joints
Intervention details:	• 40 small breed dogs (48 stifle joints) received TTAR surgery. 19/48 stifle joints received TTAR with Maquet hole, 29/48 had no Maquet hole. • No dogs received meniscal release. • No dogs received bone graft. • All dogs were on exercise restriction for 6 weeks.

Study design:	Retrospective case series
Outcome studied:	Lameness and postoperative complications at 6 weeks were measured by clinical examination and owner questionnaire assessment at mid- to long-term follow up (median 72 weeks).
Main findings: (relevant to PICO question):	• Major complication rate 7/48 (14.6%) • Infection – 1/48 (0.02%) • Medial meniscal injury noted in 19/48 (40%) • Late meniscal injury rate 2/48 (4.7%) • 2/48 developed tibial tuberosity fracture requiring surgical stabilisation • 1/19 (5.26%) stifle joints with Maquet hole resulted in tibial diaphyseal fracture • 1/29 (3.45%) stifle joints without Maquet hole resulted in tibial diaphyseal fracture • 2/48 (4.17%) stifle joints in total resulted in tibial diaphyseal fracture **PICO –** 2/48 (4.17%) developed tibial diaphyseal fracture
Limitations:	• Small sample size. • Outcome was measured by subjective client questionnaire that has not been validated. • No control group or comparison with an alternative technique. • Lack of objective outcome criteria.

Arican et al., (2017) TTAR	
Population:	Dogs receiving TTAR
Sample size:	17
Intervention details:	• 17 stifle joints received TTAR surgery with Maquet hole • All dogs received perioperative antibiotics amoxicillin clavulanic acid (8.75 mg/kg subcutaneously) • All dogs received carprofen 4 mg/kg perioperative analgesia • All dogs received 3 days postoperative meloxicam 1 mg/kg (Intramuscular) and 5 days amoxicillin clavulanic acid (undeclared dose).
Study design:	Case series
Outcome studied:	Minor complications and major complications. Lameness and pain assessment 1, 2 and 3 months postoperatively.
Main findings: (relevant to PICO question):	• Minor complication rate was 25%. • Major complication rate is 17.6% (4/17 dogs). • Tibial crest fracture occurred in 2/17 fractures; only one required surgery. **PICO** – 0/17 stifle joints receiving TTAR resulted in tibial diaphyseal

	fracture.
Limitations:	• Meniscal findings and injury rate not reported. • Minor complications were not defined. • The outcomes were measured subjectively using visual analogue scales. A clinician was used to assess outcome with blinding and control but the control was not defined. • Competency of the surgeon was not defined (specialist vs. resident vs. general practitioner). • This study has a very small sample size for assessment of complication rates. • There is no control group to assess if there would be improvement with no treatment.

de Sousa et al., (2017) Plateless TTA	
Population:	Dogs that received plateless TTA with complications of tibial diaphyseal fracture
Sample size:	17 dogs; 11/17 received Orthofoam–MMP procedure, 6/17 received TTAR procedure
Intervention details:	All 17 dogs received revision surgery to correct tibial tuberosity fracture by various forms of internal fixation.
Study design:	Case series
Outcome studied:	Outcome, major and minor complication following repair of tibial diaphyseal fracture secondary to complication of plateless TTA techniques.
Main findings: (relevant to PICO question):	• Overall complication rate – 8/17 (47%) • Minor complication rate – 3/17 (17.6%) • Major complication rate – 5/17 (29.4%) • Surgical site infection – 4/17 (23.5%) **PICO** • TTAR • N = 6 • Major complication – 0/6 • Minor complication – 2/6
Limitations:	• Small sample size – 6 TTAR and 11 Orthofoam-Modified Maquet Procedure. • Variation in surgeons managing complication – six boarded specialist vs. four RCVS Certificate qualified veterinary surgeons. • Owner compliance to original procedure was not measured or accounted for. • Incidence of these tibial diaphyseal fractures could not be determined. • No comparison with fracture complications from traditional TTA methods.

Appraisal, application and reflection

Since the advent of tTTA in 2002 (Montavon et al., 2002), various second generation TTA procedures have been invented. These techniques (TTAR, Orthofoam-MMP, MMT, TTA–2) utilise custom saw guides to aid the surgeon in producing an incomplete osteotomy of the tibial tuberosity. They have different implant designs, and they eliminate the use of a supporting plate (Ness 2016 Samoy et al., 2015, Bleakley 2015, Brunel et al., 2013). These techniques are generally aimed at the non-specialist surgeon and are marketed to be simpler than tTTA while offering comparable results. A recent case series of 17 dogs (de Sousa et al, 2017) suggests that tibial diaphyseal fractures may be a well-recognised catastrophic complication of second generation TTA techniques. However, the study design could not evaluate the actual incidence or prevalence of this complication.

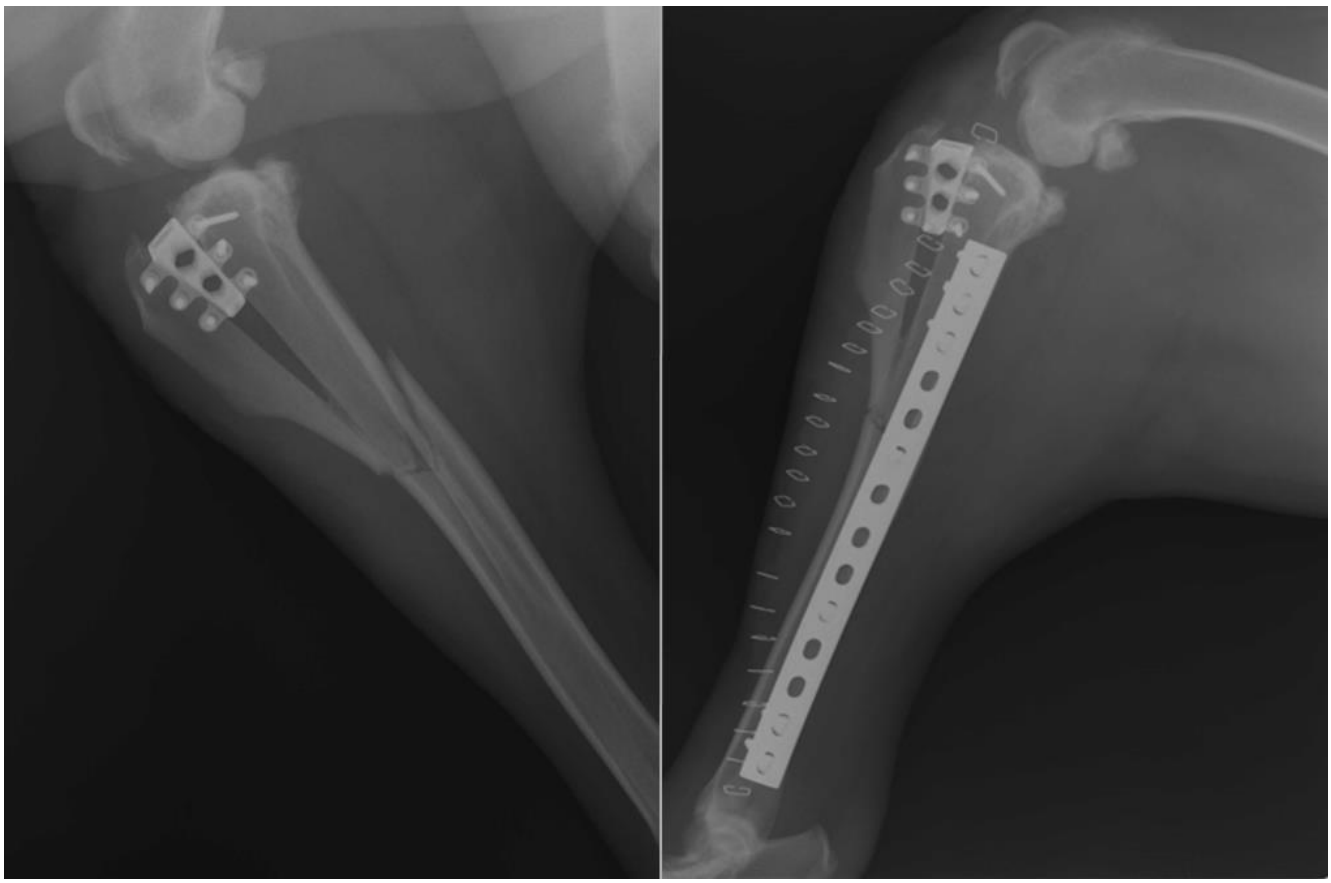

Figure 1: Example of tibial diaphyseal fracture as a complication of TTAR technique.

TTA type	Study	Tibial Diaphyseal fractures	Tibial Tuberosity Fracture	EBVM level
tTTA	Costa et al., (2017)	3/1613 (0.18%)	8/1613 (0.5%)	Level 4
tTTA	Danielson et al., (2016)	1/148 (0.7%)	4/148 (2.7%)	Level 4
tTTA	Proot & Corr (2013)	0/167 (0%)	3/167 (1.8%)	Level 4
tTTA	de Lima Dantas et al., (2016)	0/307 (0%)	2/36 (5.56%) in Boxers 1/271 (0.4%) in non-Boxers 3/307 (1%) in total	Level 3
tTTA	Kiefer et al., (2015)	2/88 (2.27%) in bilateral TTA group. 0/88 in unilateral TTA group	9/99 (9.1%) in bilateral TTA group 1/88 (1.13%) in unilateral TTA group	Level 3
tTTA	McDonald et al., (2013)	0/24 (0%)	1/24 (5.2%)	Level 4
tTTA	Hans et al., (2017)	1/91% (1.1%)	4/91 (4.4%)	Level 3
TTAR	Butterworth & Kydd., (2017)	1/152 (0.7%)	2/152 (1.3%)	Level 4
TTAR	Samoy et al., (2015)	0/50 (0%)	2/50 (4%)	Level 4
TTAR	Dyall & Schmokel (2017)	2/48 (4.17%)	2/48 (4.17%)	Level 4
TTAR	Arican et al., (2017)	0/17 (0%)	2/17 (11.7%)	Level 4

Table 2: Based on recent (< 5 years) studies relevant to the PICO, tibial diaphyseal fractures are reported in the table. While not directly related to the PICO, tibial tuberosity fractures are also included.

From this table, the rate of tibial diaphyseal fractures from tTTA (0–2.3%) compared to TTAR (0–4.17%) are roughly comparable. In the TTAR group, Dyall & Schmokel's (2017) report of 4.17% tibial diaphyseal fractures using TTAR on small breed dogs (< 15 kg) was notably higher than the other three studies. The higher fracture rate was attributed to the relatively large cage size, which may have overwhelmed the elasticity of the cranial tibial cortex, predisposing to fracture. If small breed dogs were excluded from the comparison then the rate of tibial diaphyseal fractures for TTAR would be 0–0.7%, which is within the published limits for tTTA (0–2.3%). A two-tailed T test (https://www.socscistatistics.com/tests/studentttest/Default2.aspx) comparing TTAR (0, 0, 0.7, 4.17) vs tTTA (0.18, 0.7, 0, 0, 2.27, 0, 1.1) reveals *t*-value of 0.7246 and *p*-value of 0.487105, showing a lack of significance at $p < 0.05$, although the sample size is very small.

Interestingly, tibial tuberosity fractures, while not directly related to the PICO, occur more commonly across studies. In tTTA, a complete osteotomy of the tuberosity is held in place by a forked or screw plate. Fractures are generally attributed to poor plate and cage positioning, as well as narrow tuberosity width postosteotomy (Costa et al., 2017). In TTAR, the osteotomy is incomplete leaving the distal hinge intact.

Fractures through the distal hinge were considered as tibial tuberosity fractures across the TTAR studies (Butterworth & Kydd (2017), Samoy et al., (2015), Dyall & Schmokel (2017), Arican et al., (2017)). Despite the added risk of the distal hinge fracture for TTAR, the tibial tuberosity fracture rate of 0.5–9.1% for tTTA and 1.3–11.7% for TTAR does not differ significantly at $p < 0.05$, with two-tailed T test showing *t*-value of -0.91676 and *p*-value 0.378929. In addition, the 2/50 tibial tuberosity fractures in Samoy et al. (2015) happened before the development of a dedicated saw guide. The TTAR has since been modified to exclude the use of the Maquet hole at the distal end of the incomplete osteotomy while utilising a longer osteotomy. This is facilitated by a dedicated saw guide, allowing an accurate cut. It is yet unknown if this will lead to reduced tuberosity and diaphyseal fractures.

Proot & Corr's (2013) clinical audit suggests that it takes 22 tTTA procedures to gain acceptable competence. To date, a similar clinical audit has not been published for TTAR and it is unknown if major complications such as tibial fractures are more common in the hands of inexperienced veterinary surgeons. It is also unclear from the data how often tibial fractures are due to faults in the technique or faults in the postoperative care.

It should be noted that all evidence that met the inclusion criteria for this PICO is of low grade evidence and to date no head-to-head control trials have been done comparing tTTA to TTAR or other second-generation plateless techniques. Future studies could focus on which perioperative factors might have an impact on fracture complications. For example, the experience of the veterinary surgeon, the use of bone grafting, which may accelerate healing, the size and age of the patient, which may influence bone elasticity, as well as owner compliance and protective effect of external coaptation in the early postoperative period. Based on current evidence however, the rate of tibial fractures does not differ between tTTA and TTAR. Until data to the contrary becomes available, veterinary surgeons performing either technique should be cognizant of their ability to perform complex osteotomy, as well as audit their complications and compare them against published limits.

Methodology Section

Search Strategy	
Databases searched and dates covered:	CAB Abstracts on OVID Platform 1973–Week 4 2019 Pubmed
Search terms:	(canin* or dog*) and (cruciate) and (tibial tuberosity advancement or TTA) or (TTA Rapid) and (fracture* or complication*)
Dates searches performed:	22/01/2018

Exclusion / Inclusion Criteria	
Exclusion:	CAB Abstracts via the Ovid platform covering from 1973 to 2013 weeks 1. Pubmed with publication dates > 5 years Non-english articles Articles with contents irrelevant to PICO.
Inclusion:	All TTAR papers and tTTA related papers with data pertaining to tibial fractures and complications.

Search Outcome					
Database	**Number of results**	**Excluded – non English**	**Excluded – publications > 5 years old**	**Excluded – irrelevant to PICO**	**Total relevant papers**
CAB Abstracts	48	11	15	10	12
Pubmed	37	0	17	11	9
Total relevant papers when duplicates removed					**12**

CONFLICT OF INTEREST

The author declares no conflicts of interest.

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