

1 Complications and Outcomes Associated with 13 Cases of Triceps Tendon Disruption in
2 Dogs and Cats (2003-2014)

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26 Complications and Outcomes Associated with 13 Cases of Triceps Tendon Disruption in
27 Dogs and Cats (2003-2014)

28 Abstract

29

30 This study reports data from a large number of cases of triceps tendon disruption. Records
31 from ten veterinary referral hospitals between 2003 and 2014 were searched for canine and
32 feline cases diagnosed with triceps tendon disruption, based on orthopaedic examination
33 confirmed during surgery. Long-term follow-up and owner satisfaction were assessed using a
34 questionnaire. There were 13 cases of triceps tendon disruption diagnosed across seven
35 hospitals (9 dogs, 4 cats). Trauma, history or presence of a wound, surgery in the region of
36 tendon attachment or corticosteroid treatment preceded triceps tendon disruption.

37 Radiographic signs or histopathology suggestive of a chronic tendinopathy was common. All
38 cases underwent surgical repair involving a tendon suture pattern, 12 of which were secured
39 through bone tunnels. Immobilisation was used in all cases in the form of transarticular
40 external skeletal fixation (TAESF) (8/9 dogs) or spica splint (4 cats, 2 dogs; in one dog a
41 TAESF was applied after complications associated with the spica splint). Complications
42 occurred in 11 cases (17 total complications), frequently associated with the immobilisation
43 method. One case had traumatic tendon re-rupture two years following surgery. A wound at
44 presentation was associated with the development of multiple complications. Nine cases had
45 long-term follow-up; five achieved normal function, four achieved acceptable function.

46 Despite the complications, overall return to subjective normal or acceptable function, as
47 assessed by the owners, was achieved in the majority of cases.

48

49

50 Introduction

51 Disruption of the triceps tendon is a rare condition in dogs and cats. Disruption can occur at
52 the musculotendinous junction, within the tendon or as a tendon avulsion at the
53 osseotendinous junction (Anzel and others 1959, Tarsney 1972). Tendon avulsion is when the
54 tendon pulls away from the bone, sometimes accompanied by a small bone fragment. It is
55 important to differentiate this from an olecranon avulsion fracture with an intact triceps
56 tendon.

57 To date, eleven cases (2 cats, 9 dogs) of triceps tendon rupture and/or avulsion have been
58 reported in the veterinary literature (Davies and Clayton Jones 1982, Gilmore 1984, Anson
59 and Betts 1989, Liehmann and Lorinson 2006, Clarke and others 2007, Yoon and Jeong
60 2013, García-Fernández and others 2014, Ambrosius and others 2015). A further case report
61 was in fact a cat with an olecranon avulsion fracture (Gilmore 1984). Previous historical
62 findings have been acute trauma, corticosteroid treatment or chronic lameness. Typical
63 clinical signs are non-weight bearing lameness, soft tissue swelling, pain on palpation and a
64 transverse groove in the tendon. Mineralisation in the region of the triceps tendon attachment
65 has been seen on radiographs and ultrasound in eight cases (Davies and Clayton Jones 1982,
66 Gilmore 1984, Anson and Betts 1989, Liehmann and Lorinson 2006, Clarke and others 2007,
67 Yoon and Jeong 2013, García-Fernández and others 2014). MRI findings have been reported
68 in two cases (Yoon and Jeong 2013, Ambrosius and others 2015). Surgical repair is
69 performed mostly with modified tendon suture patterns passed through bone tunnels. One
70 case of chronic tendon rupture used a mesh graft to augment the surgical repair (Ambrosius
71 and others 2015). All cases received external coaptation in various forms ranging from a cast
72 to an orthotic brace. The longest follow-up period was one year (Anson and Betts 1989). All
73 cases were reported to have normal function at the follow-up period, however, one of these

74 cases remained mildly lame (Clarke and others 2007). There have been no reports of
75 complications that have occurred post-operatively.

76 Triceps tendon rupture is also rare in humans (Balazs and others 2016, Jaiswal and others
77 2016). Acute partial injuries are often managed conservatively but complete rupture is treated
78 surgically, using transosseus tunnels (Balazs and other 2016), followed by immobilisation in
79 flexion (Tom and others 2014). A complication rate of 25% has been reported, with traumatic
80 re-rupture the most common type and wound complications being uncommon (Balazs and
81 others 2016).

82 Tendons heal slowly because they have a low metabolic rate and are relatively acellular
83 (Peacock 1959). They need to heal with considerable tensile strength without excessive scar
84 formation to allow gliding function for limb movement (Aron 1981). In chronic tendon
85 ruptures the tendinous ends contract and atrophy leaving a wide gap occupied by fibro-
86 adipose scar tissue, which needs to be excised before repairing the tendon (Us and others
87 1997). This can make the tendon repair more challenging.

88 No large case series of triceps tendon disruption in the veterinary literature has been reported.
89 The aim of this paper is to report data from a larger number of cases, with an emphasis on
90 complications of treatment and long-term follow-up. The terms 'rupture' and 'avulsion' of the
91 triceps tendon are often used interchangeably in the literature; in this study the term
92 'disruption' will be used to encompass cases of tendon rupture and tendon avulsion.

93

94 Materials and methods

95 Medical records from ten veterinary referral hospitals were searched for patients fulfilling the
96 diagnostic criteria for the time period 2003 to 2014. Diagnostic criteria were canine and
97 feline cases diagnosed with triceps tendon rupture and/or tendon avulsion, based on
98 orthopaedic examination and confirmed during surgery. Data regarding signalment,
99 aetiology, diagnostic findings, treatment and complications were assessed. Complications
100 were grouped into one of three categories; ‘minor’ requiring no further treatment, ‘major
101 medical’ requiring medical treatment or ‘major surgical’ requiring further surgery to treat
102 (Cook and others 2010).

103 Short-term outcome was assessed by veterinary orthopaedic examination. Long-term (defined
104 as more than 12 months (Cook and others 2010)) follow-up and owner satisfaction were
105 assessed using a questionnaire survey completed by the owner (Appendix 1).

106 Subjective function was assigned to one of three categories; normal function (restoration to
107 activity pre-injury without medication), acceptable function (restoration to limited activity
108 compared to pre-injury with and/or without medication) and unacceptable function (all other
109 outcomes), adapted from Cook and others 2010.

110 A Fisher’s Exact Test was performed using statistical software (IBM SPSS Statistics Version
111 22) to assess whether a skin wound at clinical presentation was associated with multiple
112 rather than single complications for dogs that had problems following tendon repair.

113

114

115 Results

116 Signalment (Appendix 2)

117 Patients fulfilling the diagnostic criteria were found in seven out of 10 referral institutions.
118 Overall 13 cases of triceps tendon disruption were reported; nine dogs and four cats. The
119 dogs had a median age of 8 years (range: 7 to 14.1 years). The median age of the cats was 4.5
120 years (range: 2.5 to 10 years).

121 History and clinical examination (Appendix 2)

122 Historical details associated with the triceps tendon disruption were recorded for all cases.
123 There was a history of trauma (5/13), bite wound and/or abscess formation in the area of the
124 triceps tendon (4/13), surgical placement of an intramedullary (IM) pin in the ulna in the
125 region of the triceps tendon for repair of a radius and ulna fracture (2/13), and a history of
126 having received high dosages of systemic corticosteroids over a period of time followed by
127 an infected wound in the region of the triceps tendon (1/13). One case had no previous
128 history of a problem associated with triceps tendon disruption.

129 Eleven of 13 cases presented with lameness; eight with acute onset lameness and three with
130 chronic lameness (defined as slowly progressive lameness). Of the two cases with no
131 recorded lameness, one case presented comatose, which meant it was not possible to assess
132 its gait. The other case had no orthopaedic abnormalities on examination; triceps tendon
133 rupture was only diagnosed during surgical repair of an abscess. Ten of 11 cases were non
134 weight-bearing lame on the affected limb. Eight of 13 cases were unable to extend their
135 elbow on clinical examination.

136 Pain in the region of the elbow (12/13) and soft tissue swelling (11/13) were the most
137 common findings on palpation. Five cases were found to have a transverse groove on
138 palpation, representing a gap between the two ends of the disrupted tendon.

139 Diagnostic imaging (Appendix 3)

140 Craniocaudal and mediolateral radiographs of the elbow were taken in 12 cases. One case did
141 not undergo any diagnostic imaging. In nine cases the radiographs revealed either soft tissue
142 swelling (6/12) and/or mineralised opacities proximal to the olecranon (6/12). In three of 12
143 cases no abnormalities were detected on the radiographs. The olecranon appeared irregular in
144 two of 12 cases (Figure 1). Enthesiophytes were visualised on the caudal aspect of the
145 olecranon in one of 12 cases.

146 In three dogs, in addition to radiography, the triceps area was examined using ultrasound
147 prior to surgery. Complete tendon avulsion was confirmed in one case and partial rupture in
148 another case. One case had abnormal fibre alignment, tendon swelling and mineralisation on
149 ultrasonographic examination.

150 Treatment and surgical findings (Appendix 3)

151 All 13 cases had primary surgical repair of the triceps tendon.

152 Ten cases (6 dogs, 4 cats) were found to have triceps tendon avulsion. Three dogs had
153 ruptured the distal triceps tendon. Disruption was partial in three cases and complete in five
154 cases. In five cases it was not stated whether the disruption was partial or complete. Debrided
155 scar tissue was submitted for histopathological analysis in one case and revealed chronic
156 tendonitis.

157 All surgical repairs involved a tendon suture pattern, 12 were secured through bone tunnels in
158 the olecranon (tendon-bone sutures). The remaining case had a direct tendon repair (tendon-
159 tendon sutures). Three tendon suture patterns (or modified versions of these, in which the
160 tendon is anchored to the bone through one or more bone tunnels) were used with the 3-loop
161 pulley or modified 3-loop pulley being the most commonly used (7/13). In 12 cases
162 concurrent paratendinous repair was reported.

163 All 13 cases had elbow immobilisation post-operatively. Transarticular external skeletal
164 fixation (TAESF) was the most frequently applied measure of immobilisation, and was
165 applied to dogs (8/9 dogs) (Figure 2). The length of time the TAESF was left in situ ranged
166 from four to eight weeks. Three type 1a TAESF and five modified type 2 linear TAESF
167 constructs were used. Two cases had a removable connecting bar enabling intermittent
168 passive physiotherapy to be performed by the owner with replacement of the bar afterwards.
169 Six spica splints were placed (4 cats, 2 dogs). In one dog the spica splint was replaced after
170 12 days by a TAESF due to skin necrosis caused by the splint, in the five other cases the
171 spica splint was maintained for three to four weeks.

172 Complications (Table 1)

173 Complications occurred in 11 of 13 cases (3 cats, 8 dogs). Four of 11 cases had more than
174 one complication. A wound at clinical presentation was associated with multiple
175 complications ($p=0.02$). Overall, 17 complications occurred, 15 were classified as major,
176 requiring medical (5/17) or surgical treatment (10/17). Two complications were classified as
177 minor, requiring no additional medical or surgical treatment to resolve. One of the most
178 common complications was pin tract discharge (5/8 TAESFs), all of these were classified as
179 major, with four requiring surgical treatment involving pin removal, replacement or complete

180 TAESF removal. The remaining case was treated medically. There were four cases of
 181 discharging wounds (4/17), one at the surgical site and three away from the surgical site. All
 182 of these were major complications. One of these cases was treated medically with open
 183 wound management, the remaining three required surgical intervention, such as debridement
 184 and primary wound closure. Three of these cases had presented with an infected wound on
 185 the elbow. Two cases developed skin necrosis secondary to the spica splint (2/6 spica splints,
 186 all dogs). Both were classified as major complications, one was managed medically, and the
 187 other case required surgery for primary wound closure. Complications in eight cases were
 188 associated with the method of immobilisation (2 cats, 6 dogs) (9/17 total complications).

189 Table 1: Causes and complications

Complications[#]	<i>Suspected or underlying causes for triceps tendon disruption</i>			
	<i>Trauma</i>	<i>History or presence of wound</i>	<i>Previous surgery</i>	<i>Unknown</i>
<i>None</i>	C13			C2
<i>Minor</i>		C3 <u>Spica splint</u> removed by animal 24 hours post surgery, which was replaced	C4 <u>Spica splint</u> - causing 10/10 lameness, resolved after splint removal 3 weeks later	
<i>Major medical</i>	C1 Lameness 8 weeks post surgery treated with NSAIDs C9 <u>Spica splint</u> - Pressure sores and skin necrosis of pes 3 weeks post surgery treated with open wound	C8 10/10 lame and pyrexia 6 weeks post surgery treated with hospitalization and intravenous antibiotics C10: 1) Discharging wound on olecranon 10 weeks post surgery	C7 <u>TAESF</u> - Pin tract discharge 2 weeks post surgery treated with cleaning	

	management	(away from surgical site) treated with open wound management		
<i>Major surgical</i>	<p>C5</p> <p><u>TAESF</u> - Pin tract discharge 4 weeks post surgery treated by TAESF removal</p> <p>C11</p> <p>1) Discharging wound on olecranon away from surgical site 4 weeks post surgery treated with dressings and delayed primary closure</p> <p>2) Irritation from tendon suture 4 weeks post surgery treated by tendon suture removal following ultrasound confirmation of advanced healing</p> <p>3) <u>TAESF</u> - Pin tract discharge 4 weeks post surgery treated with pin removal</p>	<p>C10</p> <p>2) <u>Spica Splint</u> - Pressure sores and skin necrosis over olecranon 5 days post surgery treated with debridement and primary skin closure, followed by spica splint replacement at 12 days with TAESF</p> <p>3) <u>TAESF</u> - Pin tract discharge 6 weeks post TAESF placement treated by pin removal</p> <p>C12</p> <p>1) Discharging wounds in axilla (MRSA) 2 weeks post surgery treated with wound debridement and drain placement</p> <p>2) Tendon suture failure treated with surgical revision</p> <p>C6</p> <p>1) Discharging sinus and hygroma at surgical site 11 days post surgery treated with antibiotic beads in wound</p> <p>2) <u>TAESF</u> - Pin tract discharge 11 days post surgery treated with pin replacement</p>		

190 C+number = case number, see appendix for further details

191 Underlined = complications associated with the method of immobilization (TAESF = transarticular external
192 skeletal fixator)

193 # Adapted from (Cook and others 2010)

194

195 Follow-up

196 Information about short-term outcome was available for ten cases (4 cats, 6 dogs), assessed
197 between six and 32 weeks in the cats, and between six and 14 weeks in the dogs. Findings
198 included muscle atrophy (7/10), reduced range of motion (7/10), pain on elbow palpation
199 (1/10), mild or moderate lameness (6/10) and tendon thickening (6/10).

200 Follow-up of subjective function was available for 12 cases (4 cats, 8 dogs). Eleven cases (4
201 cats, 7 dogs) returned to acceptable or normal function during the follow-up period. One dog
202 had unacceptable function peri-operatively due to the development of a major medical
203 complication. The dog developed non-weight-bearing lameness and pyrexia six weeks after
204 surgery and was hospitalised for treatment. No other complications had been noted with this
205 case and it was lost to further follow-up.

206 Long-term follow-up of subjective function (defined as >12 months (Cook and others 2010))
207 was available for nine cases, between 1.2 years and 8 years post-operatively. One dog
208 became non-weight bearing lame following a slip two years after surgery, which was thought
209 to be due to an incomplete tear of the tendon repair because there was a small gap in the
210 region of the tendon repair on palpation and the dog could extend its elbow. This dog
211 improved with conservative management but was still lame at last follow-up. Five of nine
212 cases achieved normal function and four achieved acceptable function.

213 One cat, achieving acceptable function, suffered an ulna and radial fracture on the same limb
214 one month prior to triceps tendon rupture, and subsequently also fractured the right
215 calcaneus, and later partially ruptured the gastrocnemius tendon.

216 Discussion

217 A possible cause or contributing factor for the triceps tendon disruption was identified in
218 most cases in this study (12/13), this was either as an acute incident or up to five years
219 previously. Trauma (5 cases) and prior corticosteroid use (1 case) has been formerly reported
220 as possible inciting causes of triceps tendon disruption (Davies and Clayton Jones 1982,
221 Gilmore 1984, Liehmann and Lorinson 2006, Clarke and others 2007, Yoon and Jeong 2013,
222 García-Fernández and others 2014, Ambrosius and others 2015). Corticosteroid treatment
223 whether given systemically or via tendon infiltration has been widely associated with cases of
224 tendon rupture including triceps, biceps and common calcaneal tendons (Unverferth and Olix
225 1973, Halpern and others 1977, Newnham and others 1991, Stannard and Bucknell 1993).
226 Presence and/or prior history of a wound (5 cases) or previous surgery (2 cases) in the region
227 of the triceps tendon as possible inciting causes have not been reported previously. These
228 factors may negatively affect the mechanical properties of the tendon by disrupting collagen
229 fibre alignment, thereby interfering with collagen fibre elongation and interfibrillar shear
230 (Sasaki and Odajima 1996), and therefore the tendon might be more susceptible to rupture
231 even under a normal physiological load (James and others 2008). In the two cases that
232 underwent previous surgery, tendon injury was suspected to have resulted from the proximal
233 tip of an IM pin in the ulna. Careful surgical technique by placing and bending the IM pin
234 away from the tendon attachment should be employed to minimise the risk of this
235 complication

236 Evidence of a pre-existing tendinopathy, diagnosed as mineralised opacities in the area of
237 triceps tendon insertion on radiographs or ultrasound examination, or with histopathology,
238 was observed in seven of 13 cases in this study. Imaging features of a chronic tendinopathy
239 has been identified in previous reports (Davies and Clayton Jones 1982, Gilmore 1984,
240 Anson and Betts 1989, Liehmann and Lorinson 2006, Clarke and others 2007, Yoon and

241 Jeong 2013, García-Fernández and others 2014). Two of our six cases had radiographic
242 evidence of mineralisation but no reported previous problem or chronic lameness.
243 Mineralised opacities are likely to occur through dystrophic calcification stimulated by
244 previous or repetitive trauma with disturbance of the tendon blood supply (Muir and others
245 1992). Therefore, it is possible that these two reportedly acute cases either had a chronic
246 underlying disease process or the clinical signs were subtle and had been overlooked.
247 Histopathology is needed to confirm the pathology; chronic tendonitis was diagnosed
248 histologically in one dog in this study with chronic lameness, this patient had no significant
249 findings on radiographs or ultrasound. Hence, absence of mineralisation on diagnostic
250 imaging does not rule out a chronic tendinopathy.

251 In the present study, triceps tendon avulsion occurred more commonly (10/13 cases)
252 compared with distal triceps tendon rupture (3/13 cases). Three cases in this study were found
253 to be a partial triceps tendon disruption. These were subsequently repaired surgically. In
254 humans primary surgical repair is indicated with complete triceps tendon rupture to restore
255 functional extension strength to the elbow (Singh and Pooley 2002), but non-surgical
256 treatment for partial triceps tendon rupture has been described (O'Driscoll 1992). It is not
257 known, if conservative treatment may be effective in canine and feline patients with a partial
258 rupture.

259 The data in this study is not suitable to compare the different surgical techniques used to
260 repair triceps tendon disruption, but demonstrated an overall trend to use a tendon suture
261 pattern, particularly the 3-loop pulley and its modified version (7/13), secured through bone
262 tunnels (12/13) with polypropylene or polydioxanone suture material. The available data is
263 also not appropriate to demonstrate a clear advantage of one method of immobilisation over
264 the other, but there seems to be a tendency to use spica splints in cats and a TAESF in dogs

265 for three to eight weeks. Custom made orthotic braces, as used in one recent case report may
266 offer a viable alternative (García-Fernández and others 2014), but more data would be needed
267 to confirm this.

268 In previous case reports, only one complication was documented, a non-weight bearing
269 lameness at eight weeks following splint removal in a dog (Anson and Betts 1989). In our
270 study there were a high number of complications (11/13 cases), with several complications
271 requiring medical and/or surgical intervention. It seems that many of the complications in this
272 study were related to the immobilisation method. In the triceps tenotomy study in dogs by
273 Dueland and Quenin 1980, immobilisation was not used post-operatively, but these cases
274 were controlled surgical transections with an immediate surgical repair. Due to the relatively
275 small number of cases in this study it is not possible to make firm conclusions but it did
276 appear that there were fewer complications in the cats where a spica splint was placed,
277 compared to the dogs with a TAESF placed. This highlights that early recognition and
278 treatment of complications secondary to TAESF is very important (Egger 1991), and the
279 associated importance of informing the owner about the possible risk and the signs of these
280 complications. Only one case had failure of the initial tendon repair and this is likely related
281 to the development of a multi-resistant infection post-surgery.

282 In our study there were 12 cases with follow-up information. Following limb immobilisation,
283 muscle atrophy, lameness and reduced range of motion were frequent findings in this study,
284 similar to previous reports (Anson and Betts 1989, Liehmann and Lorinson 2006, Clarke and
285 others 2007, Ambrosius and others 2015). Two cases with a removable connecting bar to
286 enable passive physiotherapy had only a mild reduction in range of motion recorded at eight
287 and 12 weeks. Both of these cases achieved normal function by six months post-surgery.

288 Three previously reported cases were found to have a successful outcome following

289 controlled increase in range of elbow motion after a period of rigid immobilisation (García-
290 Fernández and others 2014, Ambrosius and others 2015). Early mobilisation should be
291 encouraged as it places physiological loads on healing structures, reduces intra-articular
292 adhesions and helps orientate collagen fibres along lines of stress whilst increasing tensile
293 strength of tissues (Jaegar and others 2005). Gradual remobilisation enables increases in joint
294 range of motion whilst maintaining the stiffness of articular cartilage (Jaegar and others
295 2005). The use of a TAESF with a removable connecting bar assisting gradual remobilisation
296 of the elbow in dogs is an area that may warrant further research.

297 Nine cases had long-term follow-up of more than one year, this is longer than previously
298 reported. All cases achieved a good outcome; five normal function (2 cats, 3 dogs) and four
299 acceptable function (1 cat, 3 dogs). The main complication reported in human literature is re-
300 rupture of the tendon repair (Van Riet and others 2003, Balazs and others 2016). This was
301 documented in one dog in this study, with a partial tear following a slip two years after
302 surgery. This dog responded to conservative management but remained lame at the last
303 recheck three months post surgery.

304 The small number of cases and the retrospective design are the major limitations of this
305 study. These problems need to be considered when interpreting the results. In order to obtain
306 maximal case numbers for this rare condition, a multicentre approach was employed. Due to
307 this study design there are different time intervals for assessing short-term outcome. Three
308 cases were lost to further follow-up.

309 This report documents the complications and outcome of a large number of cases following
310 repair of triceps tendon disruption in dogs and cats. In addition to trauma, the use of systemic
311 corticosteroids, history and/or presence of a wound and surgery performed for fracture repair

312 in the area of tendon attachment can precede triceps tendon disruption. Diagnostic imaging
313 suggestive of chronic tendinopathy was a common finding in this study, whether or not there
314 was a history of consistent clinical signs. However, absence of mineralisation does not rule
315 out a chronic disease process and histopathology is necessary for confirmation. Surgical
316 repair with modified tendon suture patterns using the olecranon as an anchorage point was the
317 main form of primary surgical repair. Subsequently, limb immobilisation was achieved via
318 spica splint or TAESF for a minimum of three weeks. Complications were common, and
319 generally required medical or surgical intervention. There was one case of tendon re-rupture.
320 A wound at presentation was associated with the development of multiple complications.
321 Despite this, overall return to subjective normal or acceptable limb function was achieved in
322 most cases.

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401 **Legends**

402 **Figure 1**

403 Medio-lateral radiograph of the left elbow of a 10 year old female neutered (FN) domestic
404 short hair (DSH) (case 2) with presumed acute triceps tendon disruption. This radiograph
405 shows small mineralised opacities in the region of triceps tendon insertion, soft tissue
406 swelling and a roughened olecranon. The finding of mineralisation is more consistent with a
407 chronic tendinopathy, rather than an acute disruption.

408 Figure 2

409 Photo of a 7 year old FN Staffordshire bull terrier (case 7) with a type 1a hinged TAESF
410 applied to the lateral aspect of the left humerus and radius to span the elbow. The connecting
411 bar was removable to allow passive flexion and extension of the elbow.

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