

Soft-tissue injuries associated with cast application for distal limb orthopaedic conditions

A retrospective study of sixty dogs and cats

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Keywords

Cast, orthopaedic, soft-tissue, injury, complication

Summary

Objectives: Casts applied for orthopaedic conditions can result in soft-tissue injuries. The purpose of our study was to describe the nature and prevalence of such complications.

Methods: We performed a retrospective review of medical records of dogs and cats that had a cast placed for an orthopaedic condition between October 2003 and May 2009. The data were analysed and categorised.

Results: Of the 60 animals that had a cast placed, 63% developed a soft-tissue injury (60% mild, 20% moderate and 20% severe). Injuries could occur any time during coaptation, and an association with duration of casting and severity ($p = 0.42$) was not shown. Severe injuries took the longest to re-

solve ($p = 0.003$). Sighthounds were significantly more likely to develop a soft-tissue injury ($p = 0.04$), and cross-breeds were less likely ($p = 0.01$). All common calcaneal tendon reconstructions suffered soft-tissue injuries, but significance was not shown ($p = 0.08$). Veterinarians identified the majority of injuries (80%) rather than the owners. The financial cost of treating soft-tissue injuries ranged from four to 121% the cost of the original orthopaedic procedure.

Clinical significance: Soft-tissue injuries secondary to casting occur frequently, and can occur at any time during the casting period. Within our study, sighthounds were more likely to develop soft tissue injuries, and should therefore perhaps be considered as a susceptible group. The only reliable way to identify an injury is to remove the cast and inspect the limb.

coaptation as the main method of repair (6). Similarly in human medicine, this change in treatment modality has resulted in orthopaedic surgeons receiving less training in extremity immobilisation by casting. Indeed, the risks and morbidity associated with casting are often ignored or unknown, and complications occur more frequently with less experienced practitioners (7). External coaptation has several advantages over internal fixation including; no implants, decreased postoperative infection rate, minimal fracture disruption, and a possible lower cost to the client (1, 8). Complications of casting result from improper case selection, incorrect cast application, and postoperative management. They include delayed-union, non-union, mal-union, fracture disease, dermatitis, joint laxity and stiffness (1, 8, 9). Swelling and cast related soft-tissue injuries are commonly termed 'cast sores' or 'cast rubs' (1, 8, 10), but such terminology often understates the severity.

At this tertiary referral teaching hospital, The Queen Mother Hospital for animals (QMHA), there was an awareness that casts can cause soft-tissue injuries and that they occur relatively frequently. However, no source literature describing the occurrence, frequency or specific details regarding such injuries was discovered. Thus we conducted this retrospective study to document the occurrence of cast-associated soft-tissue injuries (CASTI). The aims of the study were to:

1. Identify and categorise signalment of animals and types of orthopaedic conditions for which casts were placed.
2. Categorise the prevalence and severity of CASTI.

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Introduction

Casting is frequently used as an adjunct to internal fixation in orthopaedic surgery; for instance casts can be applied in partial

or pan carpal and tarsal arthrodesis, and common calcaneal tendon repair (1–5). For the majority of fractures, treatment based on AO principles of rigid internal stabilisation have superseded external

3. Interrogate possible associations and factors for development of CASTI by simple statistical analysis.
4. Determine how CASTI were managed and the outcome for the patient.
5. Determine the financial cost of treatment for CASTI.

Materials and methods

The medical case records of animals that had a cast placed for an orthopaedic condition at QMHA between October 2003 and May 2009 were reviewed. Inclusion criteria were all dogs and cats that were treated by application of a cast, and that had follow-up information available to the point of cast removal and complication resolution. Exclusion criteria included animals in which a Robert-Jones, modified-Robert-Jones, or splinted support bandage was used as the primary mode of external coaptation. Animals with incomplete medical records up to the point of cast removal or soft-tissue injury resolution, and those being treated for soft-tissue trauma at the time of casting were also excluded.

The following data were recorded: signalment, nature of the orthopaedic condition, the resultant surgery or procedure, implants used, type of cast placed (bivalvular, univalvular) and materials used, whether the cast was placed immediately following surgery or not (and if not, the time period that a support or compressive dressing was applied prior to cast placement), the frequency of cast changes and examinations, and the intended and actual durations of cast application. Bivalvular casts had the fibreglass casing split longitudinally immediately after curing to allow later simple removal and re-application; after splitting, the two halves were secured using elastic adhesive tape then an external protective layer of self-adhesive bandage wrap was applied. Univalvular casts did not have the fibreglass split and therefore removal was impossible without destroying the cast. Cases where the intended duration was not quantified and simply defined as 'radiographic union', were not included in subsequent analysis as this term was subjective and could not be quantified into a specific duration. If a soft-tissue injury oc-

curred, this was recorded and the following data was determined: time from casting to injury, the identifier of injury (owner, veterinarian at cast change, or orthopaedic surgeon at re-examination). Soft-tissue injuries were recorded by location and categorised as follows:

- *Mild*: Superficial rubs, erythema, swelling, lesions which had only penetrated through the epidermis, those with no evidence of infection, and no specific treatment required.
- *Moderate*: Deeper lesions, those with infection confirmed with culture and sensitivity, or suspected infection (purulent exudate or comments of infection in the medical records without a culture and sensitivity result), or those requiring specific management of the injury;
- *Severe*: Tissue slough or necrosis recorded, or full skin thickness lesion, or injury which was debilitating to the animal such as lameness, or generalised signs of ill health, malaise, or loss of appetite.

Soft-tissue injuries reported on more than one occasion were considered as separate injury occurrences if they were in a different anatomical location or appeared after resolution of the preceding injury. Changes to the cast management and the time for injury resolution were also recorded (date of recorded resolution or when the injury was no longer noted).

Where possible, the cost of treatment for the original orthopaedic injury was determined in addition to the cost of managing the CASTI. The CASTI management cost was expressed as a percentage of the original cost of the orthopaedic procedure so as to normalise for annual price changes. This calculation was only applied to cases where the injuries were managed at this institution.

Statistical analysis was performed using commercially available software^{a, b}. Continuous variables that were normally distributed, which included age, duration of casting, time to resolution, duration of casting until CASTI development, were analysed with Student's T-test. Continuous variables that were not normally dis-

tributed, and which compared more than two groups, such as severity of injury and time taken for resolution, were analysed with the Kruskal-Wallis test. All ordinal variables were analysed with Fisher's exact test. All proportions are expressed with 95% confidence intervals and means \pm standard deviation.

Results

Sixty-seven animals had casts placed at this referral institution during the period examined. Only 60 had sufficient follow-up details to be included within the study.

The cast composition was polyurethane fibreglass^{c, d} in all cases. Records indicated that cast structure was bivalvular in 59 animals and univalvular in one. The dressing material beneath the fibreglass exterior included a layer of synthetic padding^e and conforming layer^f. There were no records of stockinnettes or stirrups being used.

Thirty-eight of 60 animals (63%, confidence interval (CI) = 0.51–0.74) developed a CASTI. There were 40 distinct complication episodes; two animals developed a CASTI twice whilst fitted with a cast, representing an overall prevalence of 67% (CI = 0.54–0.77). Twenty-two of 60 animals (37%, CI = 0.26–0.49) did not have a recorded soft-tissue injury and are referred to as no injury (NI) animals.

Animals that developed CASTI had a mean age of 60 months \pm 35, of which 58% (CI = 0.42–0.72) were male (32% neutered, 26% entire), and 42% (CI = 0.28–0.58) were female (29% spayed, 13% entire). Those that did not develop CASTI had a mean age of 53 months \pm 38, of which 55% (CI = 0.37–0.74) were male (32% neutered, 23% entire), and 45% (CI = 0.26–0.63) were female (27% spayed, 18% entire). A significant association between age ($p = 0.42$) or gender ($p = 1$) and the development of CASTI was not shown.

Three cats and 35 dogs developed CASTI whereas three cats and 19 dogs did

^a SPSS edition 17: SPSS Inc., Chicago, IL, USA

^b GraphPad Software Inc, San Diego, CA, USA

^c Vetcast-3M, VetLite: Animal Care Products, Loughborough, UK

^d Dynacast: BSN Medical, Hull, UK

^e Soffban: Smith & Nephew, Hull, UK

^f Easifix: Smith & Nephew, Hull, UK

Animal breed	NI (n = 22)	CASTI (n = 38)
Dogs		
Boxer		1 (2.6%)
Chihuahua		1 (2.6%)
Collie (Border & Rough)	3 (13.6%)	2 (5.3%)
Crossbreed	4 (18.2%)*	
Dalmatian	2 (9.1%)	1 (2.6%)
Deerhound		1 (2.6%)
Doberman		2 (5.3%)
German Shepherd	3 (13.6%)	2 (5.3%)
Great Dane		1 (2.6%)
Japanese Akita	1 (4.5%)	
Pointer (German Shorthaired)	1 (4.5%)	
Retriever (Labrador & Golden)	1 (4.5%)	7 (18.4%)
Rhodesian Ridgeback		1 (2.6%)
Schnauzer		1 (2.6%)
Sighthound (Lurchers and Greyhounds)		8 (21.1%)*
Slovakian Rough-haired Pointer		1 (2.6%)
Spaniel (Cavalier King Charles & Cocker)	1 (4.5%)	1 (2.6%)
Terrier (Jack Russell, Tibetan, & West Highland White)	3 (13.6%)	5 (13.2%)
Cats		
Abyssinian	1 (4.5%)	
Bengal	1 (4.5%)	
Domestic Shorthaired	1 (4.5%)	2 (5.3%)
Ragdoll		1 (2.6%)

Key: NI = no injury; CASTI = cast-associated soft-tissue injury.

Orthopaedic condition	NI (n = 22)	CASTI (n = 38)
Common calcaneal tendon injury	0 (0.0%)	6 (15.8%)
Carpal arthrodesis (partial & pan)	4 (18.2%)	8 (21.1%)
Injuries to manus	1 (4.5%)	1 (2.6%)
Injuries to pes	3 (13.6%)	8 (21.1%)
Ligament, tendon or muscle injury	4 (18.2%)	3 (7.9%)
Miscellaneous	1 (4.5%)	1 (2.6%)
Radial and ulnar fracture	2 (9.1%)	1 (2.6%)
Tarsal arthrodesis (partial & pan)	7 (31.8%)	9 (23.7%)
Tibial and fibular fracture	0 (0.0%)	1 (2.6%)

Key: NI = no injury; CASTI = cast-associated soft-tissue injury.

Table 1

Numbers of animals sorted by species and breed that had casts applied, and the subsequent occurrence of soft-tissue injuries (total numbers and proportion of group). The breeds that had a rate of occurrence of soft tissue injury that was significantly different ($p = 0.05$) to the whole group are denoted by an asterisk.

not. ► Table 1 details those cases that did and did not develop CASTI with respect to species and breed. All sighthounds developed a CASTI; this was significantly different from the sampled population ($p = 0.04$). Four dogs were categorised as cross-breeds and none of them developed CASTI; this was also statistically significant ($p = 0.01$). More Retrievers developed CASTI ($n = 7$) than did not ($n = 1$), however significance was not achieved ($p = 0.24$).

Twenty-two thoracic limb casts were placed and CASTI developed in 59% of these ($n = 13$; $CI = 0.39-0.77$). Of the 38 pelvic limb casts, CASTI were seen in 66% ($CI = 0.50-0.79$); a significant association between which limb was cast and the development of a CASTI was not shown ($p = 0.78$). Twenty-one percent of the animals ($CI = 0.11-0.37$) had more than one soft-tissue injury at the time of diagnosis. These injuries were seen in the following locations and frequencies: carpus or tarsus ($n = 13$), digits including associated pads ($n = 12$), metacarpus or metatarsus and associated pads ($n = 10$), proximal to the carpus or tarsus ($n = 10$), and location unclear ($n = 3$).

The occurrence of CASTI with respect to the primary orthopaedic conditions for casting is shown in ► Table 2. The most common reason was tarsal arthrodesis (16 cases). Animals in which a cast was applied to support a common calcaneal tendon injury ($n = 6$) all developed a CASTI, but a significant association was not shown ($p = 0.075$).

In 48 animals (80%), an implant was used in addition to the cast ($CI = 0.68-0.88$). Of these, 30 were from the CASTI group (79% of all CASTI animals; $CI = 0.634-0.89$) and 18 were from the NI group (82% of all NI animals; $CI = 0.61-0.93$) and had the following distribution: plate with screws ($n = 25$), screw(s) alone or in combination with K-wire(s) ($n = 13$), screw with nylon prosthesis ($n = 7$), suture alone ($n = 3$). A significant association between use of implants and the development of CASTI ($p = 1$) was not shown.

A postoperative support and compression bandage (typically a modified Robert-Jones) was placed in 36 cases prior to definitive casting. Twenty-five of these devel-

Table 2

Number of cases with respect to reason (primary orthopaedic condition) for which the cast was placed.

oped a CASTI and had the dressing in place for a mean of 3.9 ± 6.5 days. Eleven animals had a support dressing prior to definitive casting and did not develop a CASTI; these had the dressing in place for a mean of 2.6 ± 1.6 days. A significant association between placement of a dressing prior to casting and the development of CASTI was not shown ($p = 0.28$). Owners for 54 of the animals were advised to check the toes for swelling and redness, to monitor temperature, and to look for signs of discomfort at least twice daily. One animal's owners were advised to make these checks once daily, three animals had unclear discharge instructions, and two did not have a cast in place by the time of discharge. Written instruction to the referring veterinarian advised to remove the cast with the cast padding, inspect the limb and then replace with new cast padding and the old cast casing in the same manner that it was originally placed on a weekly basis in 54 cases, and for six cases this period was every two weeks. A significant association between the frequency of cast changes and the development of CASTI was not shown ($p = 0.19$).

The mean intended duration of casting was 32 days \pm 10 for the NI animals, and was 44 days \pm 14 for those that developed CASTI; a significant difference was not shown ($p = 0.74$). Animals that developed CASTI had the cast in place for 32 days, and those that did not had their casts in place for 38 days \pm 17; a significant difference was not shown ($p = 0.15$). A significant association between total time a cast was in place and the development of CASTI ($p = 0.33$), or the severity of the CASTI ($p = 0.42$) was not demonstrated.

Twenty incidents of CASTI (50%; CI = 0.35–0.65) were identified at the scheduled (typically weekly) cast re-applications with the referring veterinarian. Ten incidents (25%; CI = 0.14–0.40) were identified at orthopaedic re-examinations at our referral hospital (typically at six weeks postoperatively). Owners were the first to identify a problem in eight incidents (20%; CI = 0.10–0.35), and two were identified whilst hospitalised prior to being discharged home.

Sixty percent (CI = 0.45–0.74) of the injuries were mild, 20% (CI = 0.10–0.35) were moderate, and 20% (CI = 0.10–0.35) were severe. Of the eight incidents of severe

injuries, the majority ($n = 6$) were identified by a veterinary surgeon at the scheduled cast changes by the referring veterinarian ($n = 4$) or by the orthopaedic surgeon at re-examination ($n = 2$). Even when animals had severe CASTI beneath their casts, owners only detected a problem in two out of eight cases, and for these two there was a delay in seeking veterinary attention within 48 hours. All eight incidents of severe injuries required further surgery.

The mean time from casting to identification of a CASTI was 23 days \pm 17. Mild injuries were identified at a mean time of 25 days \pm 18, moderate injuries at 17 days \pm 14 and severe injuries at 26 days \pm 19. A significant difference between the time of identification of a CASTI (e.g. duration of casting) and the severity of the injury observed was not demonstrated ($p = 0.42$).

The majority of CASTI were recorded as 'pressure sores', and seen in 26/60 cases (43%; CI = 0.32–0.56). A rub or erythema was recorded as the sole injury in six of the 60 animals (10%; CI = 0.04–0.20), and erythema was seen in association with other injuries in four out of the 60 (7%; CI = 0.02–0.16). Swelling alone was seen in three of the 60 animals (5%; CI = 0.01–0.14), and swelling concurrent with other lesions in four of the 60 (7%; CI = 0.02–0.16) cases. Severe sloughing of tissue was documented in five of the 60 cases (8%; CI = 0.03–0.18). One animal lost sensation below the tarsus due to suspected neuropraxia of the peroneal and tibial nerves.

The 40 CASTI were managed in several ways. In 13 incidents, the cast was removed and replaced with a support dressing to allow ongoing wound management (e.g. flushing, topical hydrogel^g, or hydrocellular polyurethane foams^h), application of wet to dry dressings, and surgical debridement. In eight incidents, the cast was removed and replaced with a support dressing. In seven incidents, the cast remained in place with no change in management protocol. The cast was removed without further treatment or coaptation in seven cases, and in four incidents, the cast remained but with more frequent cast changes by the vet-

erinarian. A completely new cast was made in one case.

Of the 40 CASTI, six were suspected to have an infection associated with the injury but only three had a bacterial swab taken for culture and sensitivity to confirm infection; regardless of whether confirmation was obtained, all six cases received systemic antibiotics.

Once a CASTI had been identified, the cast remained in place for a mean of 9.2 days \pm 17. The mean time from identification of the injury to documented resolution of the injury was 29 days \pm 27. Mean duration to resolution was 18 days \pm 15 for mild wounds, 26 days \pm 14 for moderate wounds, and 68 days \pm 37 for severe wounds. There was a significant association between the severity of the CASTI and the time taken for resolution ($p = 0.003$).

Complete financial records were available in 15 of the 38 CASTI animals. The cost associated with management ranged from four to 121% of the cost of the original orthopaedic procedure (mean 31% \pm 32). For severe soft-tissue injuries, the cost was 69% \pm 43.

Discussion

Casting for orthopaedic conditions resulted in the majority (63%) developing CASTI. Most of those injuries (60%) were mild and included swelling, erythema, rubs and superficial abrasions, however 40% of the injuries required ongoing veterinary management. The incidence of similar injuries in man is unknown and their importance from a financial and medical defence perspective is unclear, but in the USA, 25% of malpractice claims relating to immobilisation and traction resulted in settlements of approximately US \$100,000 (7). Interestingly, ten percent of the claims were related to individuals either not being aware of, or not understanding the possible complications of casting (7).

In man, high-risk groups for cast related injuries have been identified including patients with an inability to effectively communicate and those under anaesthesia who cannot respond to heat and pressure during casting (7). Animals also have a limited ability to communicate, and casts are gen-

^g Intrasite: Smith & Nephew, Hull, UK

^h Allevyn: Smith & Nephew, Hull, UK

erally applied under sedation or anaesthesia. Therefore it is suggested that small animal patients should be recognised as being at 'high-risk' of developing CASTI.

The purpose of cast padding is to protect the soft-tissues of the limb from the pressure and friction caused by the hard cast material. Numerous different techniques for cast application including variable amounts of cast padding have been recommended, but with little scientific evidence (1, 11, 12). Recommendations vary from no cast padding in the unclipped hairy animal to two layers of cast padding, stockinette alone or varying amounts of padding. There is no consensus as to whether padding should be adjusted over bony prominences. More padding might logically protect the soft tissues better, but some argue that excess padding may lead to cast sores if the excess padding collapses and bunches thus exposing the limb to both unprotected regions and areas of high pressure (8, 12). One study investigated the effect of various permutations of cast padding on skin inflammation in dogs by measuring thromboxane-B2 concentrations; the recommendation arising from this study was to evenly apply full-length cast padding (12). Robert Jones bandages have been shown to generate high pressures on underlying tissues immediately after application but this pressure declines rapidly within minutes due to the compression of cotton and the fatigue of the elastic tape; it is possible that highly padded casts may comply in a similar fashion (13). Unfortunately in this retrospective study, it was impossible to determine either the amount of padding used, or the specifics of cast application technique, therefore no further comments on this aspect can be made. Furthermore, it can only be assumed that all casts were 'open-toe', based on all animals being discharged with instructions to inspect the toes.

Sighthounds were more likely to develop CASTI than other breeds ($p = 0.04$) therefore they may be a particularly susceptible group. It is common knowledge that these breeds have thin skin and subcutaneous tissues, especially over their distal extremities; in addition they are sparsely haired in those areas. These factors may result in them being more susceptible to

CASTI. Unfortunately there is a lack of information in the scientific literature documenting the skin structure of these dogs. As a susceptible group alternatives to casting, or practicing extreme care when casting and managing these dogs should be considered. Conversely, no cross-breed dogs developed CASTI ($n = 4$) and this was significant ($p = 0.01$). It is unclear why they appear resistant to these injuries, therefore we still advise vigilance for this group as well. Although all eight sighthounds developed CASTI and this was significant ($p = 0.04$), seven of the eight retrievers also developed CASTI and significance was not achieved ($p = 0.24$); this may be due to Type I error. With a larger sample size, statistical significance for the Retriever group may have been demonstrated.

The majority of animals ($n = 28, 47\%$) had a cast placed as an adjunct to arthrodesis surgery, of which 12 were for pancarpal arthrodesis. The surgery involved application of plate to the dorsal aspect of the carpus (compression surface), which theoretically made it mechanically vulnerable to plate bending and failure (2). Thus it was recommended in the literature that postoperative external coaptation is performed, ranging between three and nine weeks, or until radiographic arthrodesis union (2–5). There appears to be no scientific evidence in the literature that proves the need for adjunctive casting following pancarpal arthrodesis. The value of adjunctive casting for pancarpal arthrodesis may need to be questioned in light of the high morbidity shown.

All dogs that had a cast placed for common calcaneal tendon disruptions developed CASTI; this group did not include sighthounds (separately identified as high-risk). Typically the injuries were at the proximal aspect of the cast or over the dorsal aspect of the digits, which may relate to casting the limb in a hyperextended stance altering the loading on the limb within the cast thus potentiating CASTI development. Alternative immobilisation techniques for this condition such as external skeletal fixators, or practicing extreme care and monitoring if a cast is applied should be considered.

Client education in cast management has been thought to be very important and there is a burden of responsibility placed

upon owners to monitor the cast and seek veterinary advice as appropriate. Unfortunately, despite careful client education, only eight CASTI (20%) were identified by owners; of these lameness or general discomfort was noted in 75% of these and swelling of the digits in 63%. The majority (80%) of injuries, were identified at the scheduled (usually weekly) removal and re-application of the cast by the veterinarian, which suggests the only reliable method of detecting a CASTI is to remove the cast and inspect the soft-tissues. Furthermore, the low owner detection rate of CASTI indicates that features which can be assessed without taking the cast off such as lameness, malodour, digit swelling or oedema, do not seem to be reliable indicators of a CASTI. The majority of casts in this study were changed once weekly. A significant association between the frequency of cast changes and the development of soft-tissue injuries ($p = 0.19$) was not shown. Each time the cast was removed and replaced, the padding in between the cast and the skin was replaced. When changing casts it can be difficult to accurately replicate the fit between the limb, the padding and the cast that was obtained at the original cast setting. It is arguable that if cast re-application is imperfect, pressure points may develop leading to CASTI. The clinician is faced with a dilemma; detecting a soft tissue injury without removing the cast is unreliable, but regular cast removal, skin inspection and cast replacement may lead to imperfect cast fit and thereafter a CASTI. There has been work in horses investigating thermographic imaging to assess for CASTI, in which the severity of the lesion was positively correlated with a detectable change in temperature (14). Modalities looking at skin temperature as an index of vascularisation, if sufficiently sensitive, may provide an alternative way of monitoring the health of the soft-tissues below a cast without the need for regular removal. Unfortunately, such technology is currently neither available nor validated for small animals.

The cost of managing CASTI can be more than double the cost of the original orthopaedic surgery (range 17 – 125%). This estimate was based only on cases that had their CASTI managed at this institu-

tion. We recognise that this may be an under-estimate of the true cost as it was not possible to account for any additional cost incurred at the referring veterinary surgeon clinic during this period.

As commonly found with many retrospective studies, this study was limited by the accuracy and completeness of the medical records, which included missing as well as unclear data. Additionally, the role of the referring veterinarian in the management of casts adds a degree of uncertainty and makes it difficult to be sure exactly how they were managed. As there were many veterinarians involved in cast checks and we did not have access their medical records, we have assumed that the written instructions on ongoing cast management were followed consistently; but this may not have been the reality. Casting for distal orthopaedic conditions occurs relatively infrequently and consequently for this retrospective study the group sizes were small. It is therefore worth emphasising that both type I and type II statistical errors were possible in the analysis and care should be taken when extrapolating this data to bigger groups. Additionally there is potential for treatment bias as randomisation is not possible in retrospective studies of this nature. In spite of these weaknesses, this

paper has provided information on what is otherwise a poorly researched and reported but important subject. We have shown that the majority of animals cast for an orthopaedic condition developed a CASTI (63%), with sighthounds being significant more likely, and crossbreed dogs being significantly less likely. A CASTI can occur at any time after cast application and many animals develop severe injuries requiring ongoing veterinary management at considerable cost. The development of CASTI cannot be reliably identified without removing the cast and inspecting the soft tissues.

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