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Humeral intracondylar fissure and condylar fractures in dogs

Background: Fractures of the canine humeral condyle are common; they are articular fractures that require early diagnosis, accurate anatomic reconstruction and stable fixation to allow the best possible chance of a functional outcome. They most commonly occur in puppies, but can affect adult dogs too. Strong breed predispositions are recognised, with spaniel breeds accounting for most adult fractures. Many fractures in adults are preceded by humeral intracondylar fissure (HIF), a radiolucent 'cleft' at or near the isthmus of the humeral condyle. HIF can be a cause of forelimb lameness, even when it does not result in complete fracture.

Aim of the article: This article reviews the current understanding of the aetiopathogenesis of HIF and condylar fractures in dogs, describes the clinical features of both, explores decision making in diagnosis and treatment, and describes the reported outcomes.

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Epidemiology and breed susceptibility

In the UK, 60 to 67 per cent of humeral condylar fractures occur in dogs younger than 12 months of age (Denny 1983, Sanchez Villamil and others 2020), with most of these being approximately four months old or younger. A strong breed disposition is also seen, with condylar fractures being most common in English springer spaniel and French bulldog puppies (Smith and others 2020, Schettler and others 2022).

Humeral intracondylar fissure (HIF), which often precedes fractures of older dogs, has been identified in numerous breeds, including Labrador retrievers, pointers, rottweilers and French bulldogs, although spaniel breeds, particularly English springer spaniels, account for most adult condylar fracture cases. HIF has been identified in 14 per cent of English springer spaniels with no signs of forelimb lameness or elbow pain (Moores and others 2014).

Aetiopathogenesis

Currently, there is no universally accepted aetiopathogenesis for the formation of canine HIF.

The humerus develops from its cartilage anlagen from five centres of ossification. Two of these, the lateral and medial condylar centres of ossification, are believed to fuse at some stage in or after the fourth month of life, but an accurate age range and possible breed variances have not been described. As the two fronts of ossification approach each other near the isthmus, a cartilage 'plate' is temporarily present, extending from the distal humeral physis to the joint surface. This non-ossified region is likely to act as a 'stress-riser', which may contribute to the higher incidence of fractures at this age. Once the two sides of the condyle 'fuse', the risk of fracture diminishes.

HIF was once believed to occur as a result of the two centres of ossification failing to fuse, and was previously termed incomplete ossification of the humeral condyle (Marcellin-Little and others 1994). However, complete fissures have been observed to propagate from partial fissures (Witte and others 2010), and to develop in previously normal condyles (Farrell and others 2011).

Although incomplete or delayed ossification of the condyle might play a role in a minority of cases, most HIFs in adult dogs are now believed to be a form of stress fracture. Stress fractures can be fatigue fractures, whereby physiologically and structurally normal bone fractures under abnormal repetitive forces, or insufficiency fractures, when normal forces lead to fractures of compromised bone.

Anatomic factors may result in abnormal forces in the humeral condyle that could lead to a fatigue fracture. Humero-anconeal incongruity has been proposed as a cause of abnormal loading (Danielski and Yeadon 2022). Differences between spaniels with and without HIF have been demonstrated in both humeral condylar (Frapwell and others 2025) and radius/ulna morphology (Burton and others 2025).

KEY LEARNING OUTCOMES

After reading this article, you should understand:

- ☐ The current thinking on the aetiopathogenesis of humeral condylar fractures and fissures in dogs;
- ☐ How to confidently diagnose humeral intracondylar fissure;
- ☐ Factors important in clinical decision making in cases of humeral condylar fractures and fissures;
- ☐ The expected outcomes for the management of condylar fractures and fissures.

Blood vessel density in the humeral condyles of American cocker spaniels appears to be lower than in crossbreeds (Larsen and others 1999). Reduced blood supply might compromise healing of microtrauma and allow damage to accumulate, leading to fissure formation. If reduced blood vessel density preceded other condylar pathology, and was not a result of it, this would make HIF an insufficiency fracture.

In people, both heritable factors and kinematic differences are among myriad risk factors for stress fracture formation.

Clinical presentation and examination

Fractures that involve separation of one side of the condyle are called unicondylar fractures, and might be lateral condylar fractures (LCF) or medial condylar fractures (MCF). Fractures that involve separation of both sides of the condyle are called bicondylar or dicondylar fractures (DCF), or, colloquially, Y- or T-fractures. According to the literature, approximately 65 per cent of condylar fractures are LCF, 30 per cent are DCF and 5 per cent are MCF.

Many, and perhaps the majority, of unicondylar fractures occur during normal activity or after minimal trauma. The forces that result in fracture are generally 'indirect' and low energy, and so comminution is usually absent or mild, with adjacent soft-tissue injury often being minimal. Owners often report the dog 'tripping' or appearing to place the foot into a hole, but it is more likely that the humerus fractures first and the dog stumbles as a result. Some puppies also present after falling or jumping from their owner's grasp.

In adult dogs with humeral condylar fractures, there is sometimes a history of lameness in the affected limb beforehand. This is presumed to be, at least in many cases, because of a progressively unstable HIF. Mild to moderate disuse atrophy of the affected limb's musculature is often found in these cases. As HIF is often bilateral, it is important to examine the contralateral limb for any signs of muscle atrophy or elbow pain.

During the consultation for a forelimb lameness, a thorough clinical history and examination, paired with the dog's signalment, can help define the level of suspicion of HIF. Identification of these cases is important to prevent risk of a HIF propagating to a condylar fracture. All spaniel breeds presenting with forelimb lameness should be carefully evaluated for the presence of HIF. Most commonly reported clinical signs include:

- intermittent or variable lameness with variations in severity;
- episodes of severe lameness during exercise;
- severe lameness that can improve within hours.

In contrast, lameness associated with medial coronoid disease (also common in spaniels) is often worse after rest, and the variations in severity are less dramatic and occur over more protracted periods. On clinical examination, there is often pain on elbow extension and on firm palpation across the humeral condyle or over the epicondylar ridges. In some cases, the pain response is profound, which helps to differentiate from dogs with coronoid disease or osteoarthritis; however, some cases may show little pain response. It is important to carefully assess both elbows to identify cases of subclinical HIF.

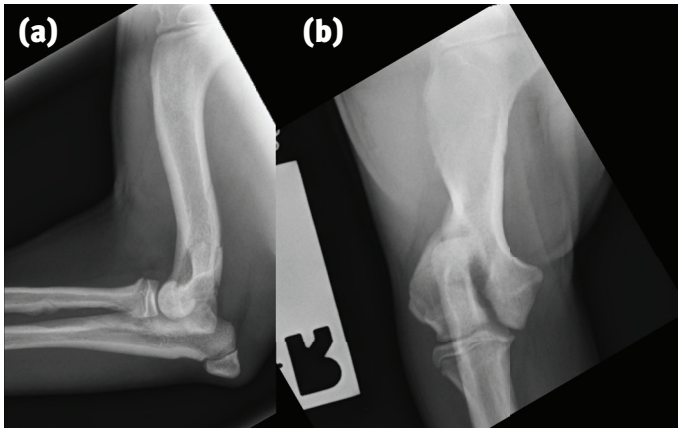


Fig 1: (a) Mediolateral and (b) craniocaudal view radiographs of a mildly displaced lateral condylar fracture in a French bulldog puppy. Orthogonal view radiographs are mandatory as fractures are easily missed on mediolateral or poorly positioned radiographs

Diagnosis

Well-positioned, orthogonal view radiographs are essential in cases of suspected condylar fractures. Fractures can be minimally displaced and easily missed in the absence of a good craniocaudal radiograph (Fig 1).

In adult dogs, it is recommended to image the contralateral humeral condyle and to inspect for the presence of HIF. Fissures can be narrow – sometimes under 1 mm – so may not be detected radiographically if the fissure is narrower than the radiographic resolution, or is not perfectly parallel with the primary beam. Occasionally, periosteal reaction of the lateral epicondylar ridge is evident in cases of HIF. A negative radiograph does not rule out HIF and therefore CT is recommended when possible.

The CT features of HIF have been described as a hypoattenuating defect through the humeral condyle (Fig 2) (Carrera and others 2008). HIFs are described as 'complete' if there is no continuity of osseous tissue across the condyle. 'Partial' HIFs always involve the articular aspect and may extend across any proportion of the condyle. Hyperattenuating areas either side of the fissure are common and represent sclerosis (Fig 2). In some dogs, sclerosis exists in the absence of a visible fissure.

Treatment

Humeral condylar fractures

The principles of articular fracture treatment apply in humeral condylar fracture cases (Box 1). Non-

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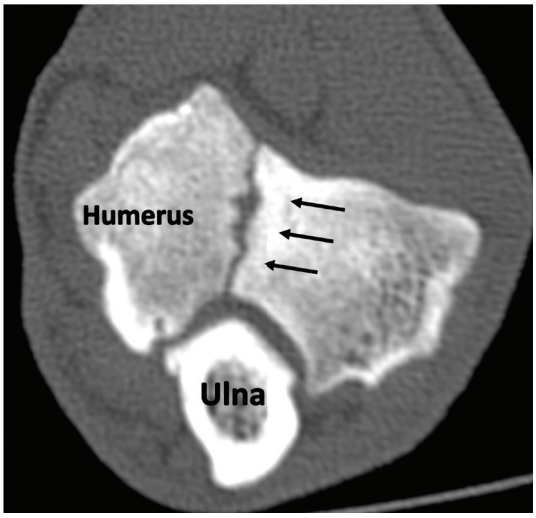


Fig 2: Transverse slice of a CT scan of a humeral condylar with a humeral intracondylar fissure. The fissure is visible as the irregular radiolucent line near the condylar isthmus. The adjacent bone has increased radio-opacity indicative of sclerosis (black arrows)

surgical management is rarely, if ever, indicated. Exceptions to this rule might be cases in which there has been a long delay between injury and diagnosis, and osseous healing has started. As a rule, fractures should be surgically stabilised within a few days of injury. Fractures in puppies will begin to heal after this period and can become challenging to anatomically reconstruct. Fractures in adult dogs, especially those secondary to HIF, are less biologically active, and satisfactory reduction can be achieved after longer delays.

Fracture stabilisation comprises two elements: the transcondylar implant and the epicondylar apparatus.

Transcondylar implant

The transcondylar implant is usually a bone screw, but might be a pin or pins in very small patients. The transcondylar tunnel is established via an inside-out or an outside-in approach. For an inside-out approach, the fractured part of the condyle is reflected to expose the fractured surface and the first half of the tunnel is established by drilling from the fracture surface. This prioritises debridement of the fracture surfaces of haematoma and fibrin, and centralisation of the tunnel, at the expense of more soft-tissue dissection. For an outside-in approach, the fracture is reduced and the tunnel is drilled from the lateral or medial bone surface. Fully threaded bone screws can be placed in positional or lag fashion. Positional screws prioritise bone-implant interface and might be less likely to loosen or result in iatrogenic fracture as the screw is tightened. Lag screws prioritise compression of the fracture surface to generate friction and load sharing. Self-compressing screws can be used to maintain bone purchase on both sides of the condyle, while also compressing the fracture.

BOX 1: PRINCIPLES OF ARTICULAR FRACTURE REPAIR

- Accurate anatomic reconstruction
- Stable fixation
- Preservation of blood supply
- Early, controlled mobilisation

BOX 2: SIGNS THAT SUGGEST A CONDYLAR FRACTURE IS SECONDARY TO HUMERAL INTRACONDYLAR FISSURE

Signalment

- In dogs older than six months of age, the assumption should be that a condylar fracture is secondary to pre-existing humeral intracondylar fissure (HIF) until evidence suggests otherwise
- In dogs younger than six months of age, the patient should be assessed for evidence of pre-existing HIF

Clinical history

- Fracture incurred during normal activity, HIF is very likely
- Significant trauma is involved in the fracture, HIF is not excluded
- Recent history of lameness in the fractured limb
- History of contralateral HIF or condylar fracture

Clinical examination

- Muscle atrophy on the affected limb
- Pain in the contralateral elbow

Imaging

- Sclerosis in the humeral condyle
- Periosteal remodelling on the fractured epicondylar crest
- A contralateral HIF

Surgical findings

- Sclerotic bone at the fracture surface

In puppies, a significant challenge is the relative softness of the juvenile, metaphyseal bone. Care must be taken to avoid iatrogenic fracture during handling, and good bone holding is an important aim of fixation. In these cases, a cortical bone screw placed in positional fashion will maximise bone-implant interface, and the use of a washer will reduce the risk of iatrogenic fracture.

In adult dogs, when the fracture is suspected to be secondary to HIF (Box 2), different priorities apply. In these cases, bone healing is often delayed and incomplete. Transcondylar implants in these cases are expected to undergo extended periods of cyclical loading before the bone becomes load sharing, if it ever does. The ideal implant would be highly resistant to fatigue failure, have excellent short- and long-term bone-holding properties, and optimise the environment for healing. Unfortunately, because of the narrow isthmus of the condyle, there is no universally accepted 'ideal' implant. In adult, springer spaniel-sized dogs, 4.5 mm cortex screws are widely used. The inside-out technique might

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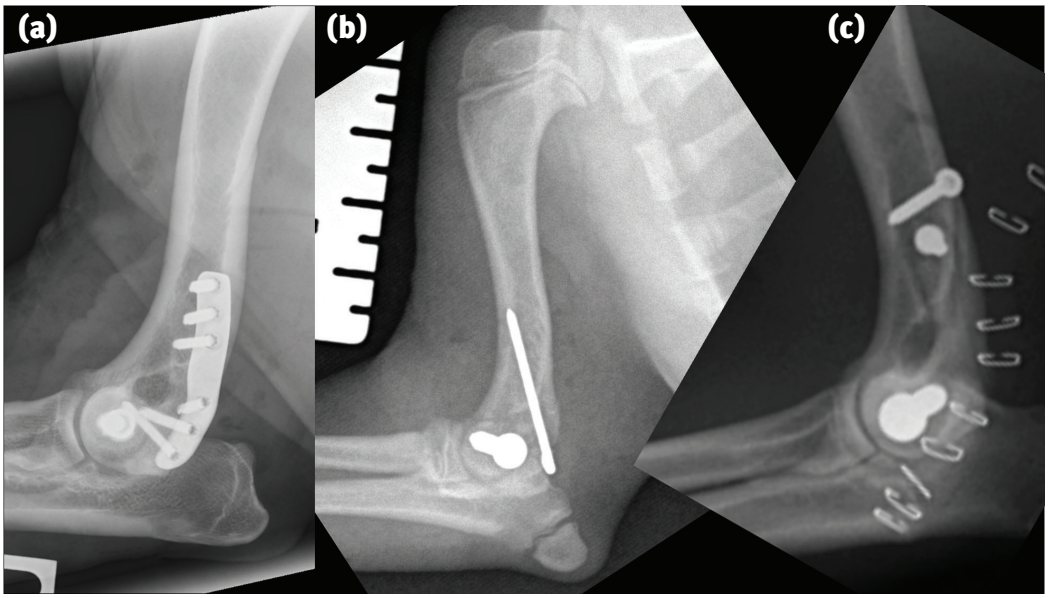


Fig 3: Options for repair of the epicondylar part of the fracture. (a) Anatomic locking plate, used alongside a humeral intracondylar repair system to treat a lateral condylar fracture (LCF) in an adult springer spaniel. (b) Pin (arthrodesis wire) used alongside a cortical screw to treat an LCF in a small breed puppy. (c) Two lag screws, used alongside a 4.5 mm cortex screw to treat a long-oblique medial condylar fracture in an adult working cocker spaniel

facilitate larger tunnels/implants as it allows direct visualisation of the fracture site, especially if intraoperative imaging is not available.

Some surgeons prioritise screw strength, and therefore diameter, for HIF and HIF-related fractures. One option is a 'shaft screw': a partially threaded screw with a smooth section diameter equal to the outer thread diameter. This increases cross-sectional area of the implant at the level of the fissure. This strength comes at the expense of bone-implant interface, potentially increasing the risk of implant loosening. Locking screws have a greater core diameter and smaller thread depth than cortex screws of a similar diameter. These implants have increased strength but weaker 'pull out' strength. Headless compression screws that prioritise strength, facilitate fracture compression and have deeper threads are available, although no clinical outcomes data is currently published.

The humeral intracondylar repair system (HIRS) is a headless, self-compressing, titanium alloy implant designed specifically for the management of HIF in springer spaniels. The HIRS allows for delivery of bone auto- or allograft to the intracondylar fracture site, and aims to promote healing (Walton and others 2020). Other condition-specific implants are available.

Epicondylar apparatus

Implant options for the epicondylar component of the stabilisation include pins, screws and plates (Fig 3). Although a plate and screws are generally preferred, pins might be appropriate when there is a small fragment size and fitting a bone plate would be challenging, such as in toy breed dogs, and in puppies where bone healing is expected to occur quickly. In adult dogs, a bone plate and/or bone screws are advised. Bone screws alone can be useful when there is a long, oblique epicondylar fracture, and multiple screws can be applied in lag fashion, creating a functional bone column that is load sharing with the implants, although the additional support of a bone plate remains preferable.

In most condylar fractures, fixation of the epicondylar part of the fracture with a bone plate is advised. Locking bone plates are advantageous as screws must engage with the metaphyseal bone distally, and use of bicortical screws in this area can be difficult. With acquired skill, generic plating systems can be contoured to fit the anatomy in most dogs. Some surgeons prefer plating systems that can be contoured around three axes to best match the bone topography, and others prefer 'polyaxial' systems that allow flexibility in locking screw direction relative to the plate.

Precontoured anatomic locking plates are available. These are breed-specific plates matching the anatomy of the lateral condyle, optimising screw hole positions and screw directions (Fig 3a, Fig 4).

Humeral intracondylar fissure

Surgery for HIF-related lameness can improve clinical signs in the short term and reduce the risk of fractures in the long term. Surgery involves placement of a transcondylar implant. In dogs with HIF but no lameness or pain, the goal of surgery is only to reduce the risk of fracture. In one study, 34 elbows in 30 English springer spaniels with subclinical HIF were followed, and six out of the 34 elbows (18 per cent) fractured, a further two elbows became painful and required transcondylar screw placement (Moores and Moores 2017). These data can be used alongside complication rates to calculate the 'number needed to treat' and 'number needed to harm' statistics that are helpful when considering treatment recommendations (Box 3).

The same considerations for transcondylar screw selection for HIF-related fractures largely apply to

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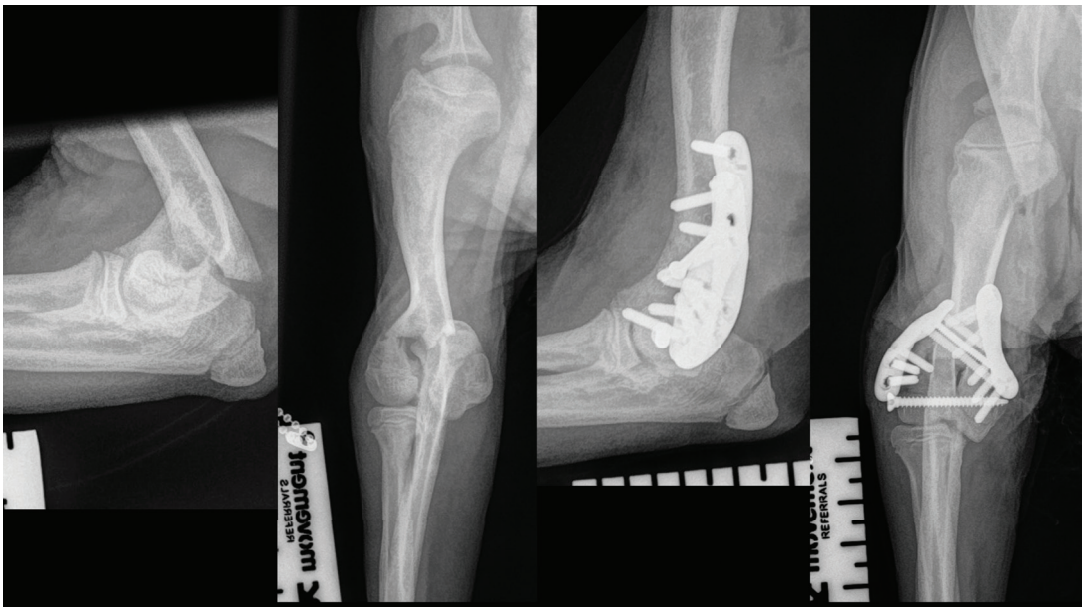


Fig 4: Medial and lateral anatomic plates used to treat a dicondylar fracture in a cockapoo

the treatment of unfractured HIF. The mechanical environment is not quite the same, and there is no risk of conflict with plate screws, but factors such as strength, bone grafting and screw pull-out strength are still important. One retrospective, multicentre case series demonstrated reduced infection risk when screws were placed in lag fashion, compared to positional fashion (Hattersley and others 2011), but a plausible explanation for this finding is not available.

Alongside implant selection, one of the most critical steps for successful HIF surgery is safely establishing the drilling position and trajectory. There are five options for establishing the transcondylar tunnel:

- The surgeon can rely on palpated landmarks and drill along the 'safe corridor', such as those described by Barnes and others (2014).
- A universal aiming device ('c-guide') can be used, which might reduce the execution error. However, generic landmarks might not be accurate in every dog so 'planning error' might remain.
- A 'custom' safe corridor can be planned in imaging software and established using a universal aiming device. This minimises both planning and execution error.
- Intraoperative imaging can be used, allowing real-time visualisation of the drilling trajectory.
- 3D printed, patient-specific, polymer drilling guides can be designed from CT data and rapidly manufactured (Fig 5).

Clinical outcomes and complications

Humeral condylar fracture

Good outcomes can be expected when non-comminuted, unicondylar fractures of the humerus are promptly surgically treated by an experienced surgeon. Reported overall success rate is approximately 90 per cent (Perry and others 2015, Sanchez Villamil 2020). Complications are common, occurring in 10 per cent to 30 per cent of cases (Perry and others 2015, Sanchez Villamil 2020). Complications are more likely to occur when pins

BOX 3: SHOULD SUBCLINICAL HUMERAL INTRACONDYLAR FISSURE BE SURGICALLY TREATED: STATISTICAL REASONING

Two statistics useful for informing clinical decision making are the 'number needed to treat' (NNT) and the 'number needed to harm' (NNH).

- NNT is the number of patients that need to be treated for one individual to have benefitted from the intervention. The lower this number is, the better.
- NNH is the number of patients that need to be treated for one individual to have suffered because of the intervention. The higher this number is, the better.

The risk of non-clinical humeral intracondylar fissure (HIF) treated non-surgically and requiring surgery for fracture or transcondylar screw placement is 24 per cent (Moores and Moores 2017). The risk for surgically treated HIFs is not known, but our best estimate is 3.5 per cent (Hattersley and others 2011). This makes the NNT (for the placement of a transcondylar screw for HIF) 4.9. That is, approximately five dogs need to be treated before one dog benefits.

For NNH, we could use major complication rates, not including screw failure (this is used in the NNT calculation). A 'major' complication is one that requires intervention to resolve, and/or a detrimental effect on outcome. NNH for non-surgical management is zero. If the major complication is 6 per cent (Hood and others 2024), the NNH would be 16.7; therefore, 17 dogs would have surgery before one suffered as a result. If the major complication rate is 20 per cent, then the NNH is five. Complication rate of a surgery is key when performing risk/benefit analysis for HIF management.

Further statistical reasoning can also be applied to determine the type of fracture that has occurred. If an English springer spaniel with subclinical HIF has an approximately 18 per cent risk of fracture (Moores and Moores 2017), and between 26.1 per cent (Sanchez Villamil and others 2020) and 45 per cent (Nortje and others 2015) of condylar fractures are dicondylar, that gives a theoretical, calculated risk of a subclinical HIF progressing to a dicondylar fracture of between 5 and 10 per cent. As dicondylar fractures are associated with higher complication rates and treatment costs than unicondylar fracture, this might be useful information for some owners when deciding on treatment options.

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are used to fixate the epicondylar component compared to screws or bone plates (Perry and others 2015). Dicondylar fractures are more challenging to stabilise, and have been associated with lower success and higher complication rates than unicondylar fractures. Despite this, positive outcomes of up to approximately 90 per cent have been reported (Nortje and others 2015).

After condylar fracture, all dogs develop some degree of osteoarthritis.

Humeral intracondylar fissure

For the surgical management of HIF, reported complication rates vary widely from 17.5 per cent (Low and others 2024) to 62 per cent (Carwardine and others 2024). Clinical outcomes are generally good, with 37 out of 41 dogs (Low and others 2024) and 24 out of 25 dogs (Hood and others 2024) reported to have returned to normal function in recent, single-centre studies. Some studies have demonstrated less consistent results, with Hattersley and others (2011) reporting that only 34 out of 53 dogs were normal, with the other 19 remaining lame.

Medial to lateral implant placement appears to be associated with a lower complication rate than lateral to medial, although not all studies support this.

There are no studies directly comparing various implant designs. Clinical success is likely dependent on establishing a safe transcondylar corridor and using an implant with sufficient fatigue resistance. Variability in complication rate makes it difficult to perform a balanced risk assessment.

Data on healing rates of HIF are limited. Radiography is not a sensitive modality to measure healing, and implant-associated artefact can compromise interpretation on CT. Where available, CT has demonstrated partial bone-opacity continuity across the previous fissure site in most cases.

Summary

Although a universally accepted theory for the aetiopathogenesis of HIF remains elusive, our understanding of this condition has advanced in recent years and influenced our clinical decision making. To address the challenging healing environment of HIFs and associated fractures there is a trend to use stronger implants or systems that allow for simultaneous bone grafting. To accommodate the stronger implants, transcondylar tunnels have increased in size, so strategies have been developed to improve placement accuracy.

Locking plates have become widely used for their mechanical advantage in this area with limited bone stock. Anatomic plates are available that aim to reduce surgical time and optimise bone purchase.

Awareness of HIF and clinical findings should improve the rate and speed of diagnosis. Prompt and appropriate management of condylar fractures ensure best possible outcomes for patients affected by these conditions.

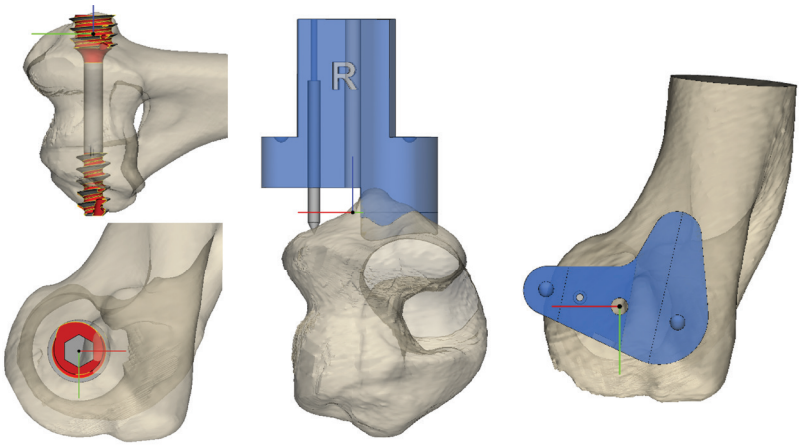


Fig 5: Computer generated images collected during the design of a patient-specific drilling guide

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Conflict of interest statement

Ben Walton is a director and share holder in Fusion Implants, a company that designs, manufactures and distributes veterinary orthopaedic implants, including those designed for the management of humeral intracondylar fissure and condylar fractures. This association has not influenced the presentation of information.

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