# Understanding why inaccuracies happen when drilling bone

**Kinley Smith**

ORTHOPAEDIC surgery may be reduced to three key factors: knowledge, understanding and accuracy. It is essential that surgeons both know and understand the rules when investigating a problem and when formulating a treatment plan. However, the most perfect plan can fail because of inaccuracies in effecting that plan in theatre. 'Measure twice, drill once' is the mantra to improve accuracy. Yet, no matter how careful the surgeon, inaccuracy can arise due to variations in equipment and technique. The more we understand these variations, the more accurate we can be.

Sequential drilling is considered to be the standard approach to creating a large diameter hole in bone, into which a large diameter (more than 3.5 mm) screw may be placed. This involves the creation of a pilot hole with a small diameter drill bit and then, using this as a guide, increasing diameter drill bits in order to reach the desired diameter. Common indications would be the placement of a humeral transcondylar screw to manage humeral condylar fissures or for a sacroiliac lag screw to treat a sacroiliac fracture luxation (Fig 1).

When compared with direct drilling using a drill bit of the final target diameter, the process of changing drill bits three or four times can be time-consuming. So why has sequential drilling become the norm in veterinary orthopaedics? Among many reasons given, the most commonly cited is improved accuracy.

In human orthopaedic surgery, the accuracy of drill alignment is commonly confirmed by the use of intraoperative fluoroscopy. Techniques include fluoroscopic orientation of a drill guide before drilling or placement of a guide wire that is checked with fluoroscopy then over-drilled with a cannulated drill bit. Enlargement of the pilot hole can then be undertaken in the knowledge the pilot hole is located appropriately. Such techniques are also described in companion animals.[1] However, for the majority of surgeons performing orthopaedic surgery in animals, the use of fluoroscopy is limited due to unavailability, cost or time pressures. Instead, we commonly rely on the intraoperative judgement of drill alignment in proximal-distal, cranial-caudal and cis-trans (depth) planes. There is no question that assessing the position of the drill tip in multiple planes is challenging.

When placing a screw in diaphyseal bone, the screw should not exceed 40 per cent of the diameter of the bone.[2] Applying this rule, if the drill hole is started in the middle of the width of the bone, small inaccuracies in the direction

## WHAT YOU NEED TO KNOW

- Sequential drilling may reduce the accuracy of hole placement compared with direct drilling.
- Angulation increases the inaccuracy of drilling, with this inaccuracy being compounded by sequential drilling.
- The median margins of inaccuracy are small when compared to the diameter of the final drill bit, but the error range is highly variable and individual errors may be large.
- While there may be a reduction in accuracy, sequential drilling may have some benefits over direct drilling.
- The decision on drilling technique should be made only after careful case-by-case consideration of the risks and benefits.

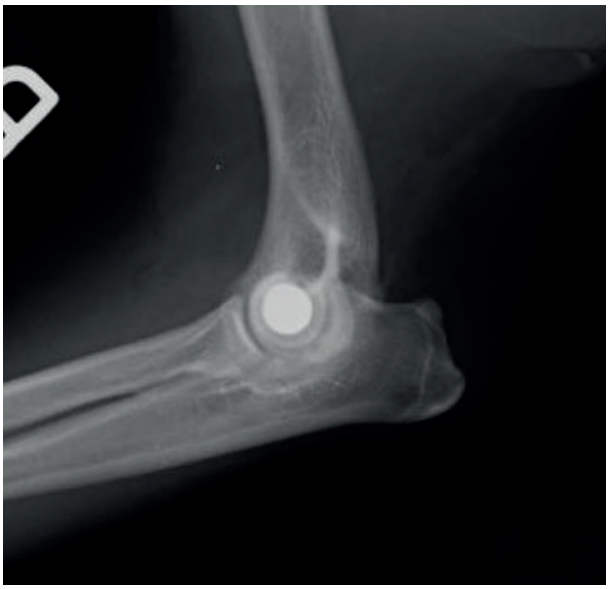
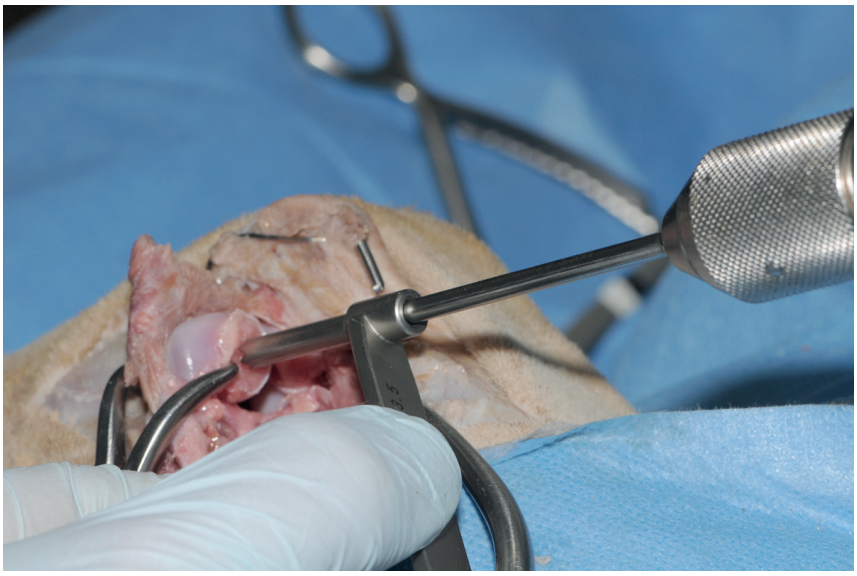


**Fig 1: Accurate placement of a humeral transcondylar screw is essential when small errors risk damaging the joint**



Photograph: C. Shales

**Fig 2: Careful and accurate drilling when repairing a lateral humeral condylar fracture is essential**

of the drill will still result in satisfactory screw placement. However, in some circumstances, such as placing sacroiliac lag screws[3] or humeral transcondylar screws (Fig 2), surgeons may choose to breach the recommended 40 per cent width limit in order to place sufficiently strong implants.

When exceeding the 40 per cent width limit, the margin for error is small.[4,5] It would take a very confident surgeon to free-hand drill a 4.5 mm drill bit for a 4.5 humeral transcondylar lag screw. Initial drilling with a much smaller drill bit offers the opportunity to make adjustments to the orientation before committing to larger diameter drills. While re-drilling to improve alignment is far from ideal, this has to be weighed against the potential for a catastrophic error through misaligning a much larger diameter drill bit.

In a study summarised on p 383 of this issue of *Vet Record*, Bishop and colleagues explore the accuracy of direct and sequential drilling in synthetic bone material.[6] The position of the final drill hole was compared to the intended position when drilling perpendicular to the material, as well as drilling at angles of 10 and 20 degrees. Contrary to expectations, it was demonstrated that the centre of the sequentially drilled hole was less accurately positioned than when drilled directly. Furthermore, the accuracy of sequential drilling was further reduced when drilling at an angle rather than perpendicular to the bone.

Bishop and colleagues demonstrated that the accuracy of drilling is reduced with angulation, and the tendency is for the centre of the resultant drill hole to drift away from the surgeon's hand. This effect is compounded with sequential drilling, which the authors consider might be expected. Drilling at an angle creates an ellipse rather than a round hole, and a larger drill bit will sit eccentrically in an ellipse, touching the far rim.

What concerns us as surgeons is not only that increasing angulation decreases our drilling accuracy, but what the magnitude of the error might be. In their data, Bishop and colleagues show that deviation from the expected centre can be up to 1.83 mm.[6] When placing a 4.5 mm transcondylar screw in a typical humeral condyle, a correctly positioned screw will have about 2.5 mm of bone surrounding it at the isthmus. An error of the magnitude described by Bishop and colleagues could potentially damage subchondral bone and, with it, cartilage health.[7]

Before recommendations are made based on Bishop and colleagues' findings, surgeons should consider the aspects of sequential drilling that may be superior to direct drilling with large diameter drill bits. A healthy screw-bone interface is critical to the success of a bone screw, be it a lag, positional, plate or suture anchor screw. Many iatrogenic factors affect the screw-bone interface, such as drill blunting or damage, drilling speed, drilling pressure and the resulting torque.[8] Thermogenesis is demonstrated when drilling bone with large diameter drill bits, and sequential drilling is considered to reduce the maximum temperature.[9,10]

However, there is a paucity of research into the effect of drilling directly into canine cancellous or cortical bone with large diameter drill bits. Experimental studies on the structure and health of canine bone should be considered before we can make absolute recommendations. There are practical considerations too. Some drills will not have the torque to drill directly with large diameter drills, and such constraints may be important where access to equipment is limited.

Given sequential drilling and angulation lead to inaccuracy, what steps might the surgeon take to minimise these effects? At the planning stage, we might seek to minimise the need for

Photograph: B. Oxley/ vet3d.co.uk

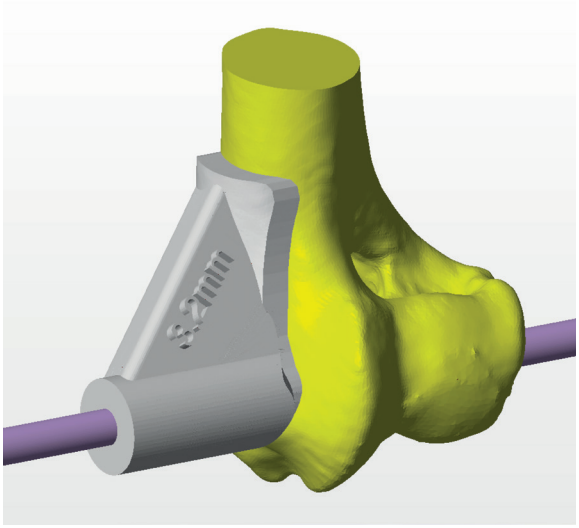



**Fig 3: Planning a patient-specific drill guide to ensure accurate placement of a humeral transcondylar screw**

angulation. However, it is rare this can be possible in cases where large diameter screws are required as the anatomy of the bone usually influences the direction of drilling. Bishop and colleagues suggest starting drilling perpendicular to the bone before angulation, although this has not been tested and must be carried out with extreme care to avoid damaging the cis cortex. Ensuring the planned screw position is taken as accurately as possible to the bone is vital, and the surgeon might consider fluoroscopy or mechanical guides. Additionally, these techniques may permit direct drilling. Another valuable technique to improve accuracy is the generation of patient-specific 3D printed drill guides from computed tomography scans (Fig 3). In many circumstances, these permit accurate drilling of bone regardless of screw diameter.[11,12]

An orthopaedic surgeon must know and understand the factors that influence the accuracy of drilling a hole in bone. For each case the surgeon must take into account the risks and benefits of each drilling technique, choosing the most appropriate method for the procedure, the surgeon's experience and the available equipment.

**Kinley Smith,** MA, VetMB, CertSAS, DipECVS, PhD, MRCVS

Willows Referral and Veterinary Centre, Highlands Road, Solihull, B90 4NH, UK

email: kinley.smith@willows.uk.net

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