



## **Agreement and reliability of femoral varus measurements: a comparison of four techniques**

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Agreement and reliability of femoral varus measurements: a comparison of four techniques

# Femoral varus: what's the angle?

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## Conclusions and clinical relevance

- **'Symax' method is simple to perform**
- **Measured varus does not vary much with femoral angulation, as seen before<sup>1</sup>**
- **Femoral angulation has least effect on 'Symax' compared to other tested methods**
- **Repeatability for an experienced observer was good for all methods**
- **Observed differences may be clinically irrelevant**
- **Logical next steps: effect of observer experience, interobserver variation**



## Abstract

Three different techniques have been described for measuring femoral varus radiographically in the dog, but how the measurements from these techniques compare is unknown. Further, measurement reliability has only been assessed for one technique.

Seven grossly normal right femora were radiographed with the diaphysis positioned horizontally and inclined at both 12.5° and 25° to the horizontal. Radiographs were blinded, randomised and read twice by one observer using ImageJ. Using coordinate data, varus angles were calculated using Microsoft Excel for the three previously reported techniques and a novel method, which we believed would be more reliable. Reliability between readings was assessed using the within-subject standard deviation and repeatability coefficient, and the effect of angulation on varus measurement was assessed using a mixed model ANOVA.

Two of the reported techniques varied significantly ( $P < .05$ ) with femoral angulation, increasing by approximately 2° from horizontal to 25° angulation. At 25° femoral angulation the novel technique differed significantly (nearly 2°,  $P < .05$ ) from one of the reported techniques, but otherwise results were similar for all methods. Although we hypothesised that the novel method would be more reliable than the other techniques, all values for the within-subject standard deviation and repeatability coefficient were broadly similar. Graphically, the novel method appeared to vary least with femoral angulation in this population, and its simplicity may offer advantages for clinical use. In the absence of an absolute cut-off for surgical intervention for femoral varus, none of the observed differences are necessarily clinically significant.

## Introduction and objectives

Excessive femoral varus can contribute to medial patellar luxation in dogs, along with other anatomical abnormalities. Varus can be assessed radiographically. Some clinicians insist on radiographs taken with the femora parallel to the radiographic film, whereas others are satisfied with a hip extended view in which it is unlikely that the femora are truly parallel to the film, but instead are angled away from it. A recent report has highlighted small but significant changes in measured varus with femoral angulation.<sup>1</sup> In addition, three measurement methods have been described,<sup>2-4</sup> and there is no consensus on which should be applied or if they produce comparable results.

### Research questions:

**Which method's results alter least with femoral angulation?**

**Which method is most repeatable?**

**Does how we measure varus matter?**

The study objective was to answer these questions.

## Methods

Seven grossly normal right femoral bone specimens were radiographed with the diaphysis inclined at 0°, 12.5° and 25° relative to the radiographic plane.

Varus was measured using three published methods ('Dudley', 'Tomlinson', 'Swiderski')<sup>2-4</sup> plus one novel method ('Symax') on two occasions after blinding and randomisation. The freely available software ImageJ was used for all measurements in combination with custom acetate overlays. The same distal femoral reference line was used for all methods, ensuring a true comparison of variability and repeatability.

Coordinate data from ImageJ were converted to varus angles using a custom macro in Microsoft Excel. Data were analysed using repeatability coefficients,<sup>5</sup> and a mixed model ANOVA in SAS.



## Results

### Variation with femoral angulation:

Methods 'Tomlinson' and 'Swiderski' increased significantly from 0° to 25°, by about 2°.

The novel 'Symax' method varied least with femoral angulation. Variation was generally small for all methods, as shown by the ANOVA results and graphically (see chart).

### Differences between methods:

Methods 'Dudley' and 'Symax' were significantly less than 'Tomlinson' at 25°, by about 2°.

No other statistically significant differences were observed.

### Repeatability:

Within-subject standard deviations were small (0.5°-0.9°) indicating low variation between readings.

Repeatability was similar for all methods with 95% of paired measurements expected to be within 1.4°-2.2° of each other.

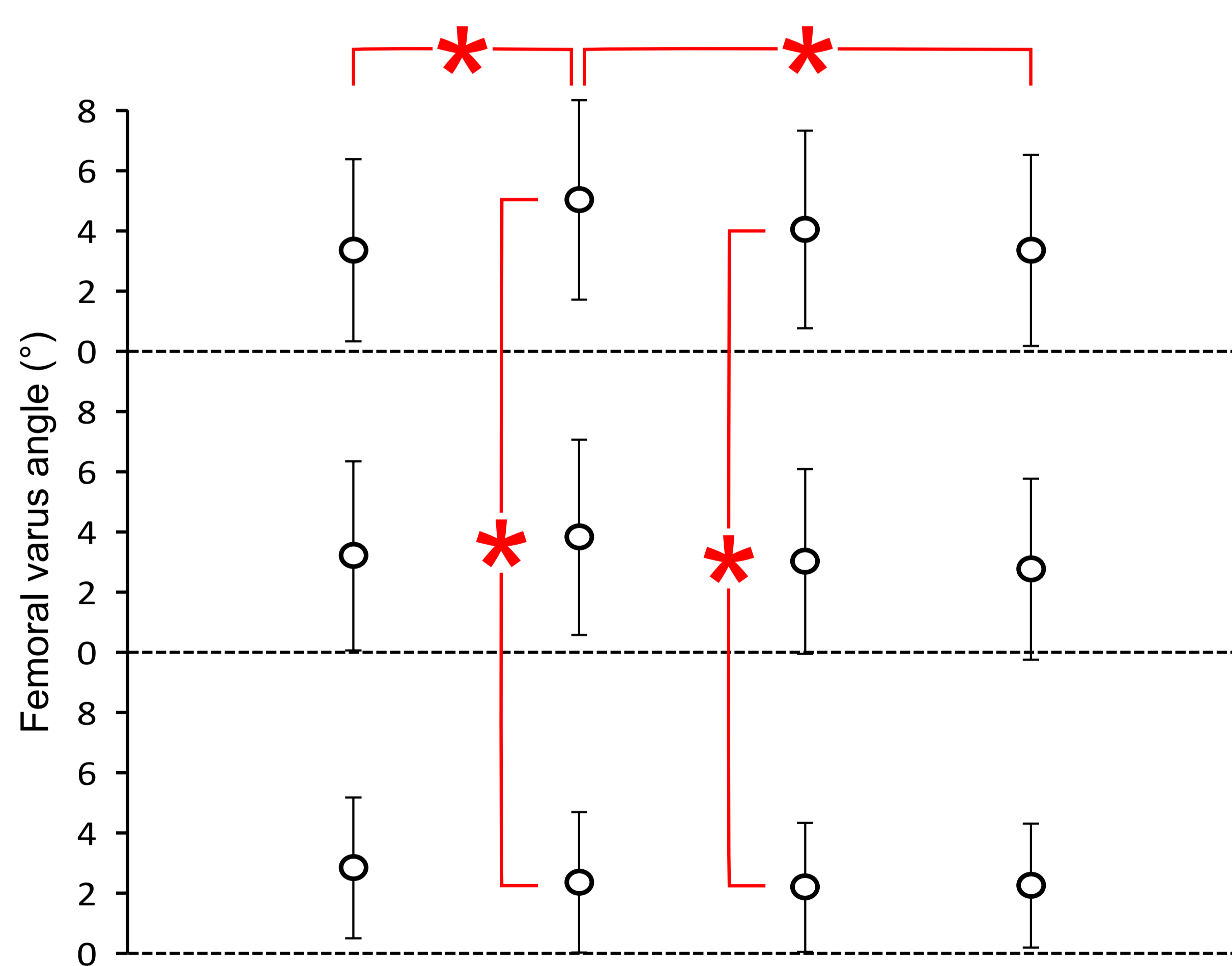
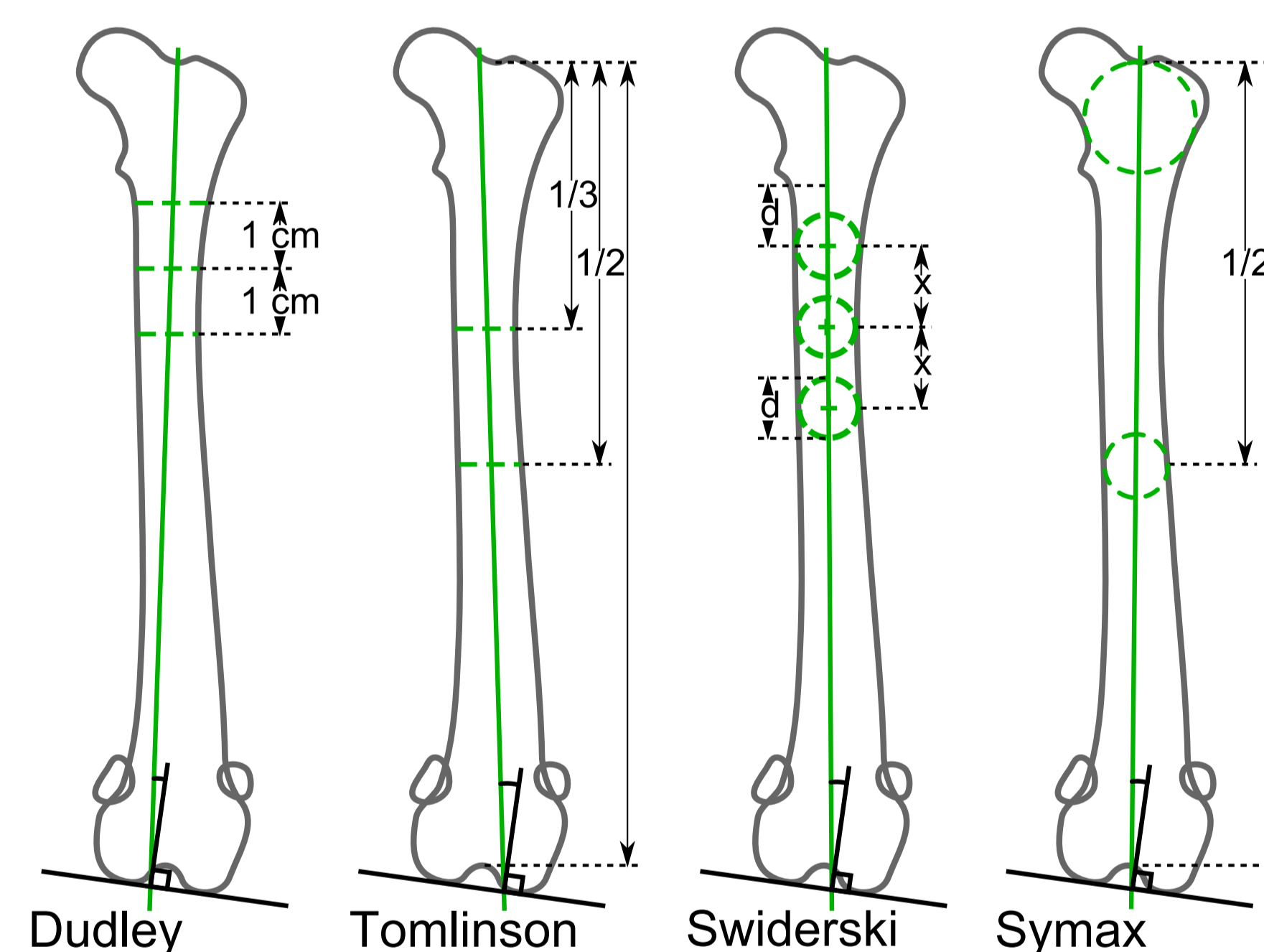
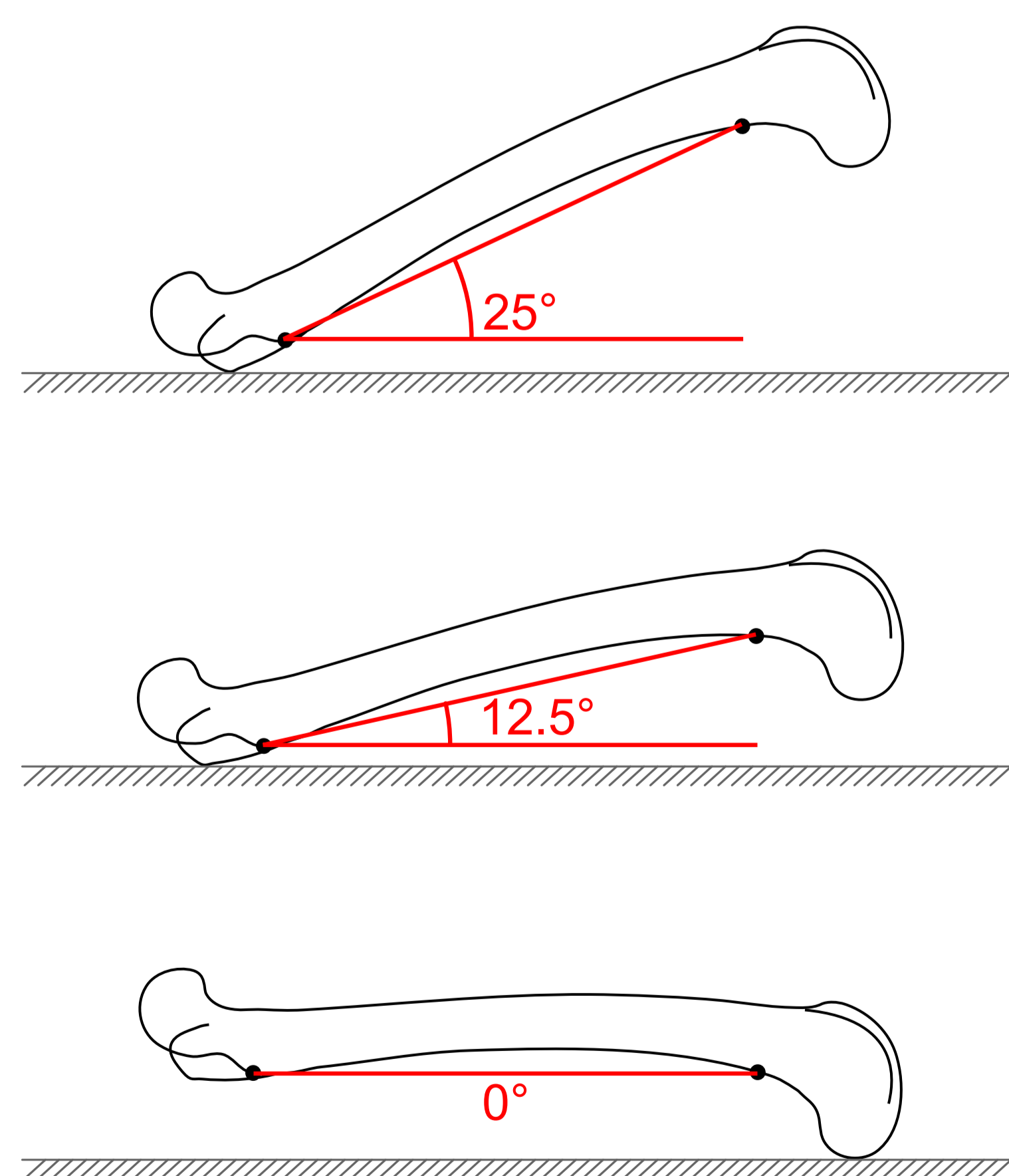
## Varus measurement methods and values

Radiographic femoral varus measurements for the four methods and three angulations are shown. Values are arranged in columns according to method, and in rows according to angulation. Error bars represent one standard deviation.

Significant differences ( $P < .05$ ) are marked with a star.

Each method's definition of the anatomic proximal femoral axis (aPFA) is illustrated above the chart. Where fractional distances are shown, these refer to the diaphyseal length (unlabelled arrows). The aPFA differs subtly between the four study methods.

Femoral angulation was measured between a line joining the lesser trochanter and supracondylar tuberosity, and the horizontal, as shown in the illustrations to the left of the chart.



## Further information

### Literature:

1. Jackson and Wendelburg (2012) Evaluation of the effect of distal femoral elevation on radiographic measurement of the anatomic lateral distal femoral angle. *Vet Surg* 41:994-1001
2. Dudley et al (2006) Radiographic and computed tomographic determination of femoral varus and torsion in the dog. *Vet Radiol Ultr* 47(6):546-552
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4. Tomlinson et al (2007) Measurement of femoral angles in four dog breeds. *Vet Surg* 36: 593-598
5. Bland and Altman (1996) Statistics notes: measurement error. *BMJ* 313: 744

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