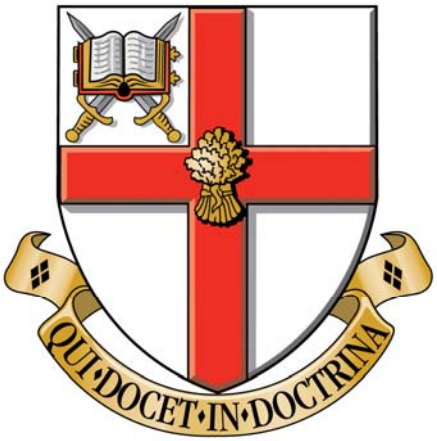

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A method for measuring robusticity in long bones

Stephen Lewis

Abstract
The robusticity of a long bone is usually determined by dividing its width at its mid-point by its length. Finding this mid-point can be cumbersome. Using two-dimensional radiographic (or photographic) images, it is possible to find the mid-point of a bone quickly and easily using the transparent overlay tool described.

Introduction
A measure of the robusticity (or relative slenderness (Parish, 1966)) of long bones is usually expressed numerically as the ratio of width divided by length. For convenience, this ratio may also be expressed as a percentage. The point at which the width is measured may be at the point of minimum width (Parish, 1966) or at the mid-point of the bone's shaft (Scheuer and Elkington, 1993). For purposes of standardisation, methods where the measurement of width is made at the mid-point are preferable. To determine the mid-point, however, usually entails measuring the bone length, dividing that value by two and measuring that length back onto the bone from one or other of its ends. This approach allows the introduction of error at two, or even possibly three, stages. There will be a certain degree of error in measuring the overall length of the bone and when half that value is measured back. The extent to which one must round either of these values up or down may add further error.

When measuring three-dimensional objects, measurement error may also occur in any of the three planes of orientation. By using radiographs or photographs taken under strictly standardised conditions, three-dimensional objects may be reduced to two-dimensional images which are inherently easier to handle and use on repeated occasions with the added advantage that there can be no damage to the original specimen. Here, since one is using a flat two-dimensional representation of a bone, one can bisect the bone geometrically, using compass and ruler, in the classical fashion (Appendix 1). The chief argument against this approach is that it tends to be cumbersome, especially if one has numerous images upon which to work.

A tool and method for finding the centres of linear objects
A simpler and quicker method of finding the midpoint of a long bone, or any other linear structure, is to use a transparent plastic overlay bearing the design shown in Figure 1. This tool consists of a piece of transparent acetate with two diverging straight lines drawn upon it. The angle between these two lines is bisected by a third line. Perpendicular to this bisector are a series of parallel lines. These lines are used to orientate correctly the long axis of the bone being measured, while the bisector is used to find its midpoint.

This tool is cheap and simple to construct and to use. It also provides a means whereby the radiograph (or photograph) being measured can be protected during measurement - especially if one is using sharp-pointed callipers. Furthermore, by using the same tool on a series of bones, an overall consistency of technique is ensured throughout the series of measurements taken.

Procedure

To measure the robusticity of a long bone using its radiographic or photographic image:

1. Place the overlay on the image and align it so that the long axis of the bone is parallel to the series of parallel lines and so that the points at each end of the bone — between which the bone's length is to be measured — are each on one of the two diverging lines (Fig. 2).
2. Measure the length of the bone between the two predetermined end-points.
3. Measure the width of the bone, along the line of the bisector, where it crosses the ends of the shaft of the bone.
4. Determine robusticity using the equation:
   Robusticity = (Width/Length) x 100

A whole family of such tools may be constructed with diverging lines of differing angles, lengths and sizes suitable for different bone sizes. To construct this tool, one may draw any pair of conveniently diverging lines and bisect the angle they subtend in the classical fashion (Appendix 2). Alternatively, one may use a computer-aided drawing or design package, as was used for all the Figures given here, for quick and accurate results.

Corollary

It is also possible to find points at other distances proportional to a bone's length using a version of the tool such as that in Figure 3. It should be pointed out, however, that since these extra lines will not be perpendicular to the long axis of the bone, one should not measure along them but construct the appropriate lines.

References

Parish, J. G. 1966 'Radiographic measurements of the skeletal structure of the normal hand.' *British Journal of Radiology* 39: 52-62.

Scheuer, J. L. and Elkington, N. M. 1993 'Sex determination from metacarpals and the first proximal phalanx.' *Journal of Forensic Sciences* (JFSCA) 38: 769-78.

Figure 1 – A tool for finding the centre of long bones (enlarge to required size)

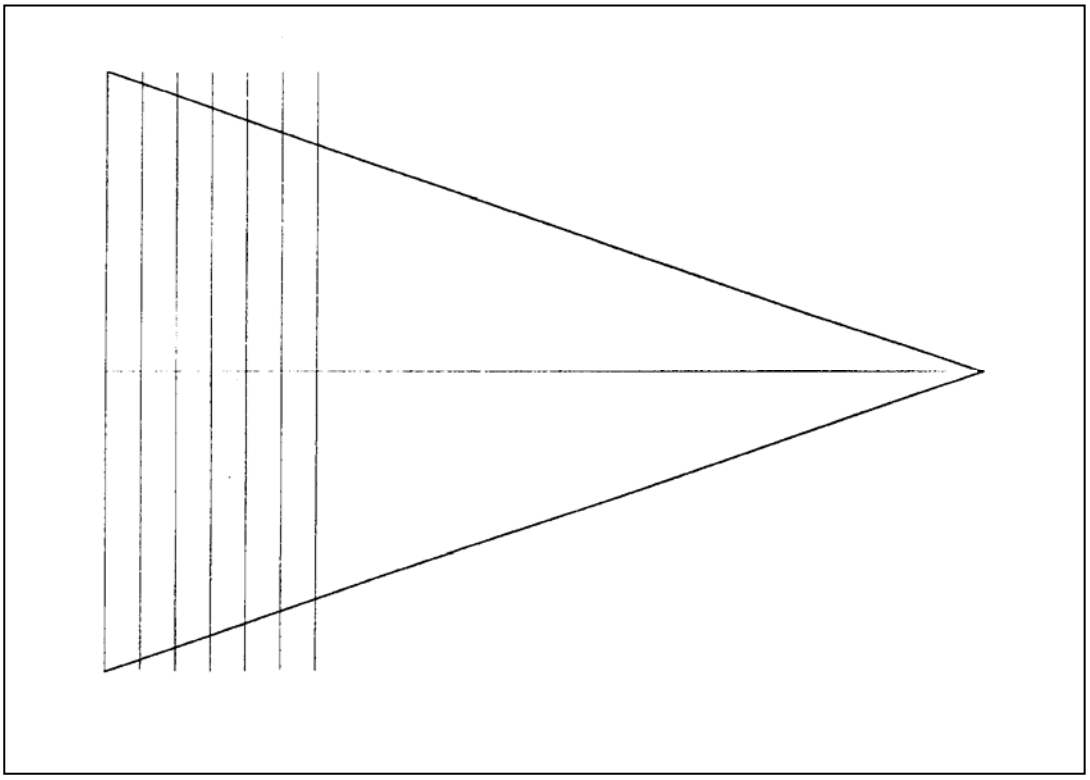


Figure 2 – The tool in use

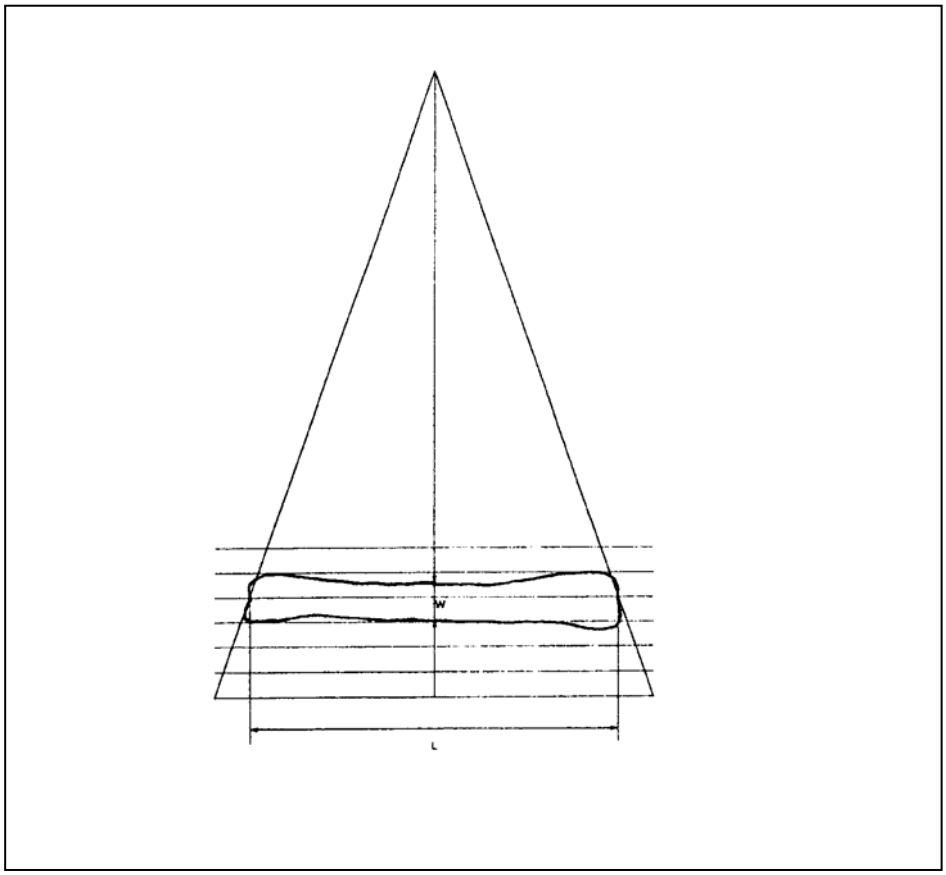
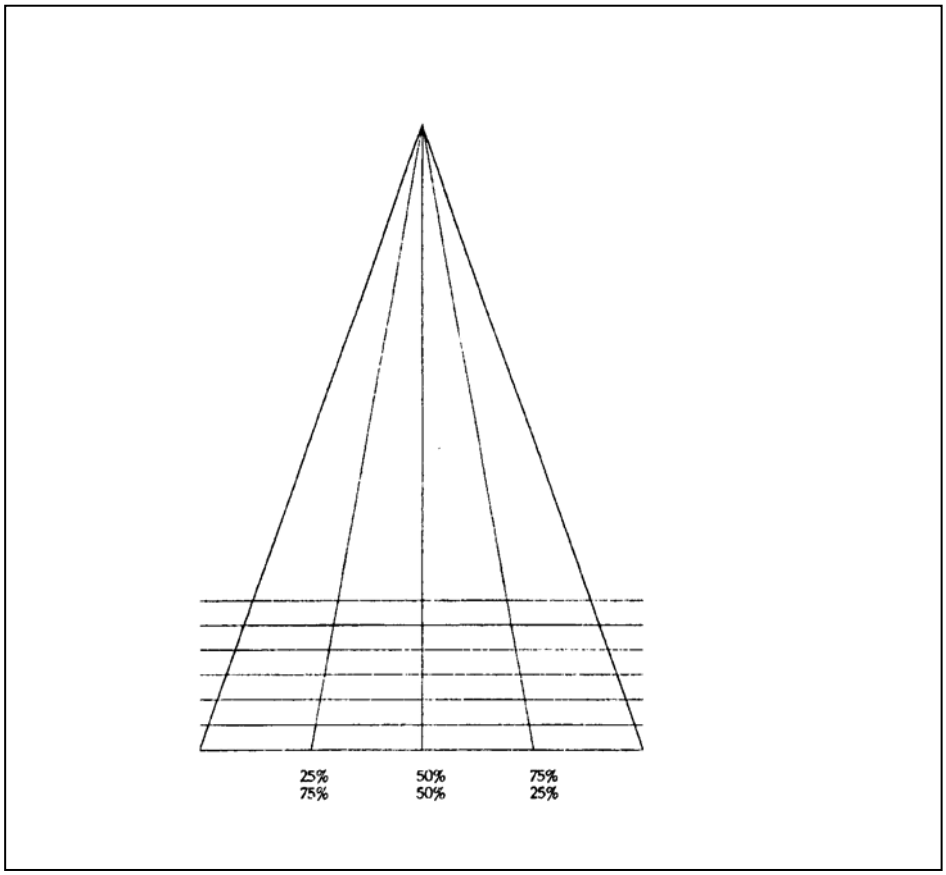
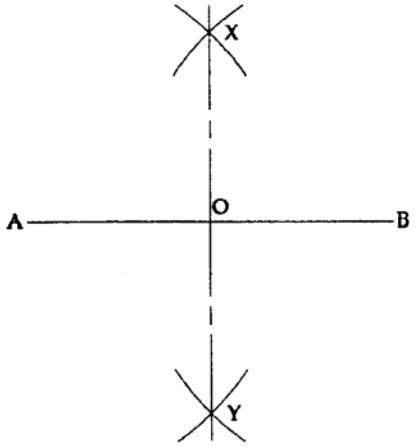


Figure 3 – A modification to the tool



Appendix 1



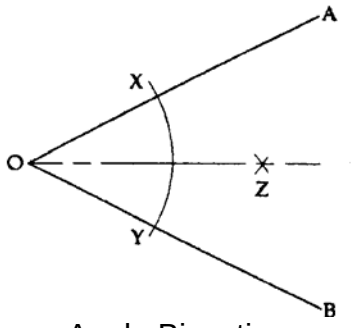
Line Bisection

Given AB, a straight line which it is required to bisect:

(1) With centres at A and B in turn, and with a radius greater than half the length of line AB, draw arcs of a circle such that they intersect at X and Y.
(2) Join X and Y cutting AB at O

- O is the mid-point of line AB.

Appendix 2



Angle Bisection

Given AÔB, an angle which it is required to bisect:

(1) With centre at O, draw an arc of a circle of any convenient radius, such that it cuts AO and BO at X and Y, respectively.
(2) With centres at X and Y in turn, draw arcs of a circle - both of the same radius * such that they intersect at Z.

- The straight line through O and Z bisects the angle AÔB.