Appendix

Equation 2:

Calculation of mediolateral and anteroposterior dimension of the rotated ellipse.

$$Ax^2 + By^2 + Exy + F = 0$$

$$A = s^2M^2 + r^2N^2$$

$$B = s^2N^2 + r^2M^2$$

$$E = 2(s^2MN - r^2MN)$$

$$F = -r^2s^2$$

"s" and "r" are defined as the distances from the centerpoint of the drill hole to the points of intersection of the rotated ellipse along the y and x-axes, where the y and x-axes run parallel to the anatomical anteroposterior and mediolateral axes, respectively.

There are two ellipses, the original one lined up with the anteroposterior and mediolateral axes and the other rotated ellipse.

Using the equation above:

$$(s^2M^2 + r^2N^2)x^2 + (s^2N^2 + r^2M^2)y^2 + 2(s^2MN - r^2MN)xy + (r^2s^2) = 0$$

For L, solve for where the ellipse intersects the x and y coordinates. Into the above equation plug in x = 0, and solve for y (for the width, plug in y = 0 and solve for x).

$$y^2 = (r^2s^2)/(s^2N^2 + r^2M^2)$$

$$x^2 = (-r^2s^2)/(s^2M^2 + r^2N^2)$$

$$Length = 2y$$

$$Width = 2x$$

Equation 3:

This equation is based on a 9-mm drill-bit drilled with a 45° sagittal drill angle. Thus, the bone tunnel aperture is elliptical with a length of 12.7 mm and a width of 9 mm.

1. Define ellipses

Ellipse 1 (Equation 3.A)

$$x_1 = a\cos(t)\cos(\frac{\phi}{2}) - b\sin(t)\sin(\frac{\phi}{2})$$

$$y_1 = b\sin(t)\cos(\frac{\phi}{2}) + a\cos(t)\sin(\frac{\phi}{2})$$

Ellipse 2 (Equation 3.B)

$$x_2 = a\cos(t)\cos(-\frac{\phi}{2}) - b\sin(t)\sin(-\frac{\phi}{2})$$
$$y_2 = b\sin(t)\cos(-\frac{\phi}{2}) + a\cos(t)\sin(-\frac{\phi}{2})$$

Where a = 6.35 and b = 4.5, as the semi-major and semi-minor axes.

2. Find intersection of the two ellipses by setting:

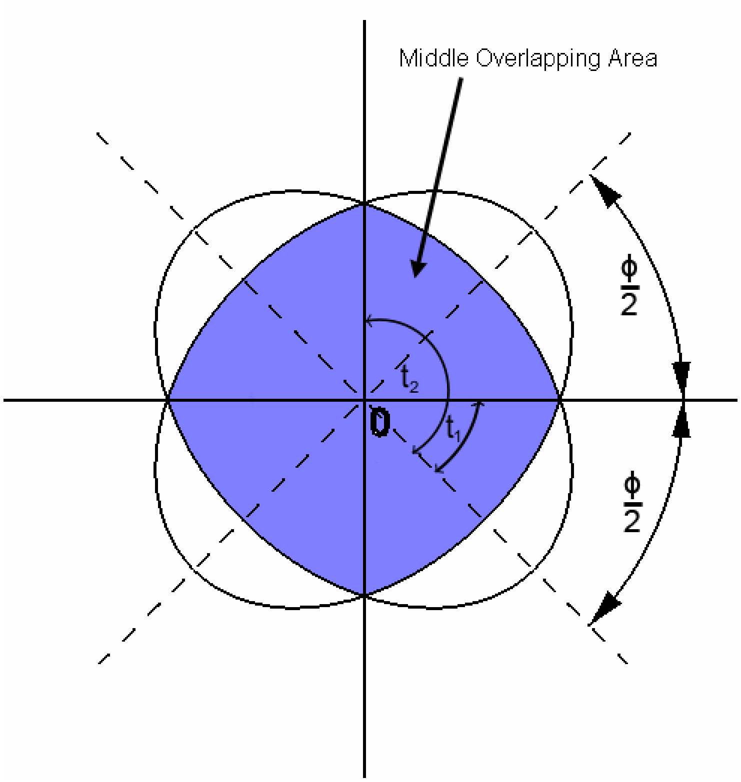
$$x_1 = 0$$
$$y_1 = 0$$
$$x_2 = 0$$
$$y_2 = 0$$

In Equations 3.A, 3.B solve for (t_1, t_2), the two angles at which Ellipse 1 intersects with Ellipse 2 (this occurs on the X and Y-axes). The angles (t_1, t_2) are counterclockwise and relative to the major axis of Ellipse 1. The portion of the middle overlapping area for the first quadrant is calculated as:

$$A(t_1, t_2) = \int_{t_1}^{t_2} r^2 dt$$

Where: $$r^2 = \frac{a^2b^2}{b^2\cos^2 t + a^2\sin^2 t}$$

The area for the first quadrant is multiplied by 4 since we have symmetry about both major and minor axes of the ellipse. The nonanatomic aperture area of the ellipse is found by subtracting the middle overlapping area from the total area of the ellipse. The total area of an ellipse is given by: $\text{Area}_{\text{ellipse}} = ab\pi$.


Middle Overlapping Area
t_2
t_1
0
$\frac{\phi}{2}$
$\frac{\phi}{2}$