An Active Shape Modeling Based Tool for Semi-automated Xray Assessment

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OBJECTIVES

- Develop an active shape modeling tool to identify features in radiographs and take measurements
- Assess the reliability and accuracy of the measurements compared to standard manual measurements.

METHODOLOGY

Training the Model

Thirty-six post-operative radiographs of implanted Oxford Unicompartmental Knee tibial trays were used to train the model applying the methodology detailed by Cootes *et al.* [1]. Points outlining the tibia (n=64) and tray (n=53) were selected for each image (Figure 1), 20 further points were interpolated between each point couple. Shapes from each image were aligned using the Procrustes method, (Equations 1-3) and principal component analysis performed on the shapes and surrounding greyscale values.

$$Translation = \frac{1}{N}\sum_{i=1}^{N} x_i$$

$$Rotation = \frac{1}{N}\sum_{i=1}^{N} \tan^{-1}\frac{y_i}{x_i}$$

$$Scale = \frac{1}{TibialWidth}$$

Equations 1-3: Where x and y are the co-ordinates of the points and N is the total number of points.

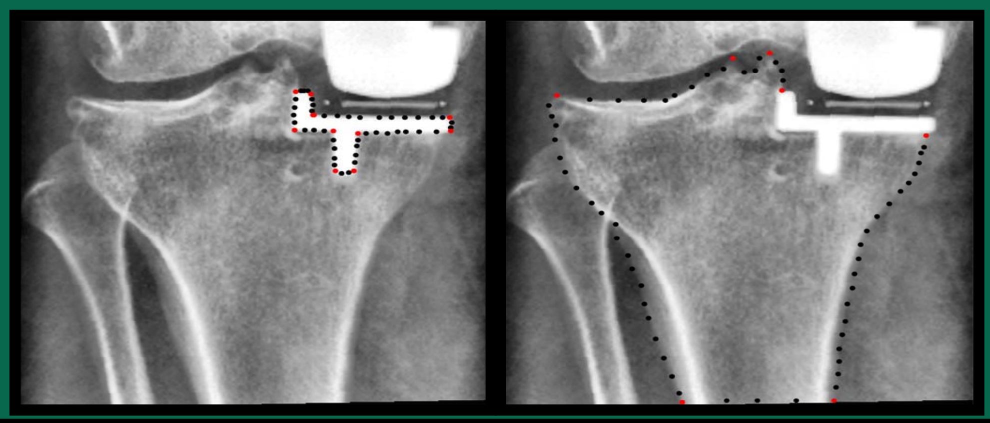

Figure 1: Example landmark points chosen to represent the shape of the tibia and tibial tray

Measurements

The measurements which were taken of the tibial tray are summarised in figure 3. (1) is the angle of the tray to the horizontal. (2) is the distance the tray overhangs the edge of the bone. (3) is the size of the tray. (4) is the distance from the sagittal cut to the mechanical axis. (5) is the resection level and (6) is the width of the tray. The same measurements were taken manually and using the ASM 4 times each to allow assessment of the intra-observer reliability.

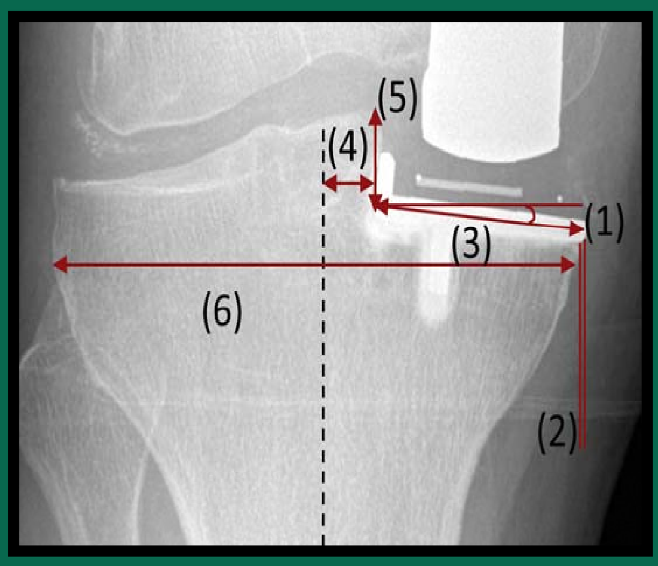

Figure 3: Summary of the measurements taken from the post-operative radiographs.

Application of the Model

Prior to application the user could flip/invert the radiograph and rotate/resize the average shape and then select a starting position. Once the model was applied, 40 iterations were used and at each application the program calculated the pixel profiles for the current points and then moved the point to a new location which minimised the Mahalanobis distance. Once the shape was found, the mechanical axis of the tibia was determined ; the image was then rotated to be in line with the axis and cropped to the proximal tibia. The scale of the image was identified by fitting a circle to the spherical portion of the femoral component, which was a known size (Figure 2).

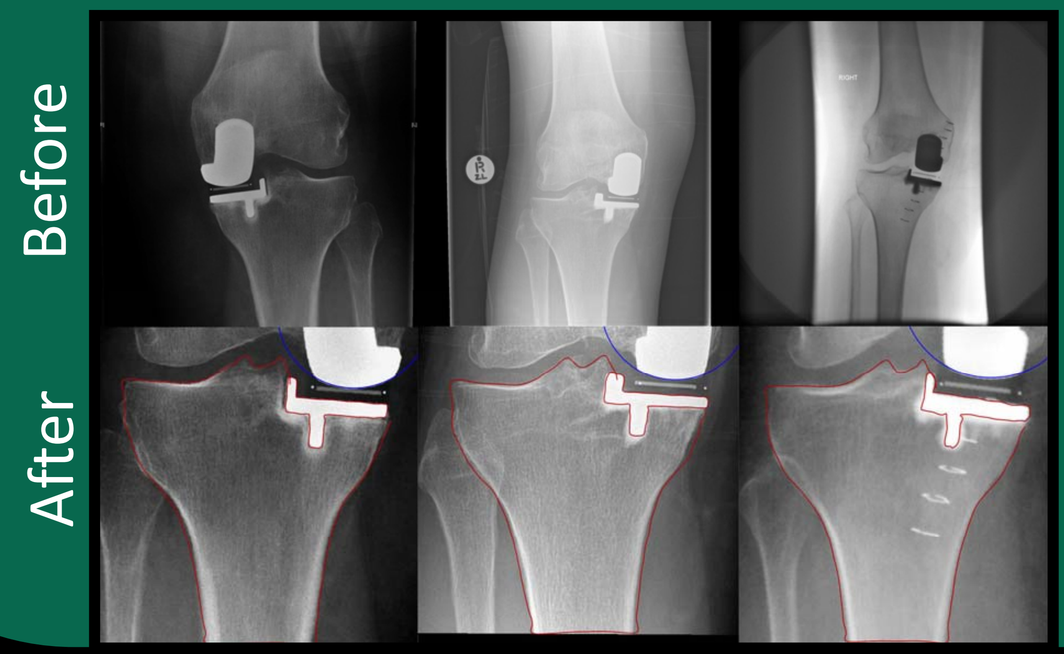

Figure 2: Illustration of three radiographs before, and after application of the ASM.

RESULTS

The ICC results were on average 27% higher for all the ASM datasets compared to the manual data and this difference was significantly significant (Mann-Whitney t-test, p=0.018, Figure 4). A good correlation was observed between the measurement values of the ASM compared with the manual measurements for all parameters with the exception of the degree of tray overhang (Table 1).

Measured Parameter	p
Tray angle	0.6590
Tray overhang	0.0001 *
Size tray	0.5900
Sagittal cut position	0.9630
Resection level	0.2950
Tibial width	0.8550
Pixel size	0.0820

Table 1: Paired t-test results comparing ASM measured data to manual measurements.

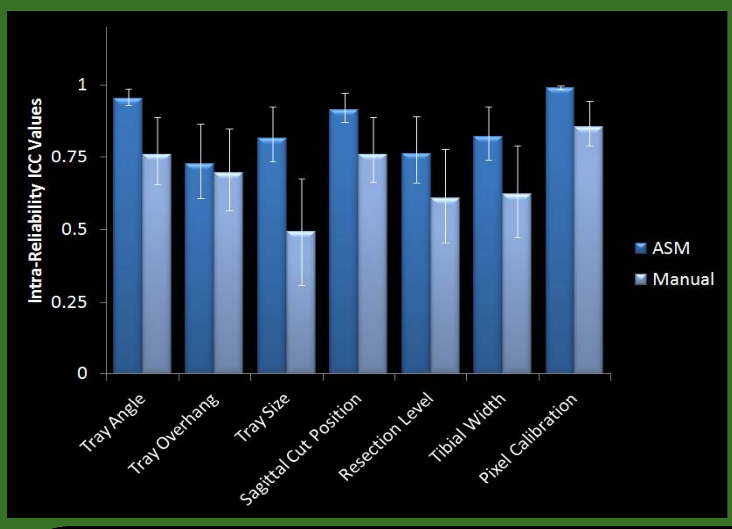

Figure 4: Intra-observer ICC results of different measurements parameters using the ASM and manual measurement method.

[1] Article In Press: Pegg EC, *et al.* Improved radiograph measurement inter-observer reliability by use of statistical shape models. Eur J Radiol (2011), doi:10.1016/j.ejrad.2011.12.018

CONCLUSION

The ASM measurement technique enabled measurement of radiographs with reduced labour, equivalent accuracy and improved reliability for all parameters , with the exception of the tray overhang. This is a promising result and with further optimisation of the algorithm it is hoped and this technique could prove useful for quick analysis of radiographs [1].

ACKNOWLEDGEMENTS

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