Citation for published version:
Pegg, E, Pandit, H, Dodd, CAF, Murray, D & Gill, H 2012, 'An Active Shape Modelling Based Tool for Semi-Automated Xray Assessment' Orthopaedic Research Society Annual Meeting, San Francisco, USA United States, 4/02/12 - 7/02/12, .

Publication date:
2012

Document Version
Publisher's PDF, also known as Version of record

Link to publication

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

+[1]Pegg, E C; [1]Pandit, H; [1]Dodd, CAF; [1]Murray, DW; [1]Gill, HS
+[1]University of Oxford, Oxford, UK
elise.pegg@ndorms.ox.ac.uk

INTRODUCTION:

Measurement of component alignment is essential for the assessment of surgical outcome. Examination of post-operative radiographs to determine component positioning and bone quality surrounding components is generally a manual process. The introduction of digital X-ray imaging systems has increased the measurement tools available; however, manual selection of measurement points is still required. This can introduce subjectivity in the measurements and can be labour intensive in large studies.

The aim of this study was to try to address this issue by developing a computer method to semi-automate the assessment of radiographs, enabling several measurements to be taken at once through the use of active shape modeling. This study examines the specific case of the Oxford™ Unicompartmental Knee replacement (UKR); however, the method can be applied to the assessment of a number of joint replacement devices. This paper will outline the method used for the analysis and preliminary results investigating measurement accuracy and reliability.

METHODS:

Active shape models were used to automate the measurement of position of implanted Oxford™ Unicompartmental Tibial Trays (Biomet UK Ltd., Bridgend, UK) from post-operative radiographs . The software used to create the models was MATLAB (version 7.10, MathWorks Inc., MA, USA). The models were trained using 36 post-operative radiographs of proximal tibias after UKR. The program was then evaluated by taking measurements of 19 additional radiographs which were not part of the training set. Each of these radiographs were examined twice to determine the intra-observer reliability.

The model used active shape models to obtain the co-ordinates of the outline of the tibia and the implanted tibial tray (Figure 1); these co-ordinates were then used to perform the measurements.

Figure 1. Illustration of the completed active shape model fitting of the tibia and the tibial tray (outlines shown in black).

The active shape model methodology used was based upon the technique reported by Cootes *et al.*[1]. To train the models, points outlining the tibia (n=53 points) or the tibial tray (n=48 points) were selected. Twenty points were then interpolated between the landmarks resulting in 1198 co-ordinates. Prior to application of the model the user could rotate the average shape and resize it, then the starting position was selected. When the model was applied to the image, 40 iterations were used, 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.

The images were calibrated using the femoral component; this was defined using an edge detection method and a least squares circle fit for the spherical portion of the component. The femoral component size was input by the user.

From the shape model coordinates, several measurements were made. The mechanical axis of the tibia was defined as the line between; the centre of the most distal medial and lateral points, the centre of the furthest medial and lateral points on the proximal tibia and the tip of each tibial spine. The angle of the tibial tray was then measured in relation to the mechanical axis. The degree of tibial tray overhang was measured as the distance from the most medial point on the proximal tibia to the edge of the tibial tray. The size of the tibial tray was measured as the distance from the wall of the tray to the edge. The distance of the wall of the tibial tray from the mechanical axis was measured. The depth of the tibial cut was assessed through measurement of the distance from the centre of the tibial spines to the centre of the base of the tibial tray, in line with the mechanical axis.

To assess the accuracy of the calibration method, the measured size of the tibial tray was compared to the known size of the implanted component.

An intra-observer reliability assessment was performed between the two measurement sets for all parameters to determine the reliability of the method. A two-way mixed model was used and the single measure intraclass correlation (ICC) was calculated using PASW Statistics (version 18.0.0, SPSS Inc., Chicago, IL). An ICC value less than 0.40 was considered poor, 0.40-0.59 fair, 0.60-0.74 good and 0.75-1.00 excellent [2].

RESULTS:

The maximum error found in measurement of the size of the tibial tray ranged from -8.0 mm to 0.6 mm; the mean error was -2.0 mm (*ca.* 7% of mean tray size) and the standard deviation in the error was 2.3 mm (*ca.* 8% of mean tray size).

The ICC values and 95% confidence intervals were calculated for each of the measured parameters (Table 1). The ICC values for the size of the tibial tray was considered good and all other values were considered excellent.

	Intraclass Corrrelation Coefficient (ICC)	95% CI	
		Upper	Lower
Tray Angle / degrees	0.947	0.867	0.979
Tray Overhang / mm	0.912	0.788	0.965
Size Tray / mm	0.719	0.404	0.881
Distance Tray to Axis / mm	0.894	0.747	0.958
Depth Cut / mm	0.777	0.509	0.908

Table 1. Summary of the ICC values and corresponding upper and lower 95% confidence intervals for the different parameters measured.

DISCUSSION:

The mean measurement error in the size of the tibial trays was negative, indicating that this measurement technique overestimated the width of the tibial trays, on average. The main reason for this is likely due to the angle at which the X-ray is taken; several of the trays were not in line with the X-ray beam and would be overestimated as a result. Therefore, the measurement errors found here are unlikely to be solely due to error in calibration of the image. Further work is therefore necessary to determine error in the calibration of the image; this will be performed using calibration markers of a known size.

The intra-observer reliability test illustrated the repeatability of this method. All but one of the ICC values were greater than 0.75 and were excellent; the lowest ICC value was for the size of the tray, but this was still good.

The semi- automated method allows for consistent measurements with relatively little labour time. Further tests, including inter-observer reliability tests, comparison with manual measurements, and further validation of the calibration method currently being performed.

SIGNIFICANCE:

This preliminary work outlines a method to automate radiograph measurements which are important for assessing surgical outcome. By decreasing the labor time and subjectivity in measurements, a greater quantity of reliable data could be obtained. This data could be used to improve evaluation of surgical technique and may enable the discovery of trends relating to patient outcome leading to improvements in treatment.

REFERENCES:

[1] Cootes, TF. et al. *Comput Vis Image Und.*. 61:38-59 (1995).
[2] Shrout, PE, Fleiss, JL. *Physchol Bull*. 86:420-428 (1979)