Deep Learning Artificial Intelligence Tool for Automated Radiographic Determination of Posterior Tibial Slope in Patients with Anterior Cruciate Ligament Injuries

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INTRODUCTION:

An increased posterior tibial slope (PTS) corresponds with an increased risk of graft failure following anterior cruciate ligament (ACL) reconstruction. Validated methods of human PTS measurements are subject to potential interobserver variability and can be inefficient on large-scale sets of images. The purpose of this study is to develop a deep learning artificial intelligence technique for the automated measurement of PTS from standard lateral knee radiographs.

METHODS:

A deep learning U-Net model was developed on a cohort of 300 postoperative short leg lateral radiographs from ACL reconstruction patients to segment the tibial shaft, tibial joint surface, and tibial tuberosity. The model was trained via a random split following an 80:20 train-validation scheme. Masks for training images were manually segmented and the model was trained for 400 epochs. An image processing pipeline was then deployed to annotate and measure the PTS using the predicted segmentation masks. Finally, the performance of this combined pipeline was compared to human measurements performed by two study personnel using a previously validated manual technique for measuring PTS on short leg lateral radiographs on an independent test-set of consisting of both preoperative and postoperative images.

RESULTS:

The U-Net semantic segmentation model achieved a mean Dice similarity coefficient of 0.885 on the validation cohort. The mean difference between human-made and computer-vision measurements was 1.92º (σ = 2.81º, P=0.24). Extreme disagreements between human and machine measurements as defined by differences ≥5º occurred less than 5% of the time. The model was incorporated into a web-based digital application front-end for demonstration purposes which can provide measurement of a single uploaded image in portable network graphics format in less than 5 seconds.

DISCUSSION AND CONCLUSION:

We developed an accurate and reliable deep learning computer vision algorithm to automate the measurement of PTS on lateral knee radiographs. This tool will be deployed for clinical use on an institution-wide basis and, pending external validation, be made available to outside orthopaedic surgeons, who will now have an efficient and accurate tool to measure PTS as part of the preoperative assessment of ACL-injured patients.