Deep Learning Automation of Revision TKA Fixation Zones

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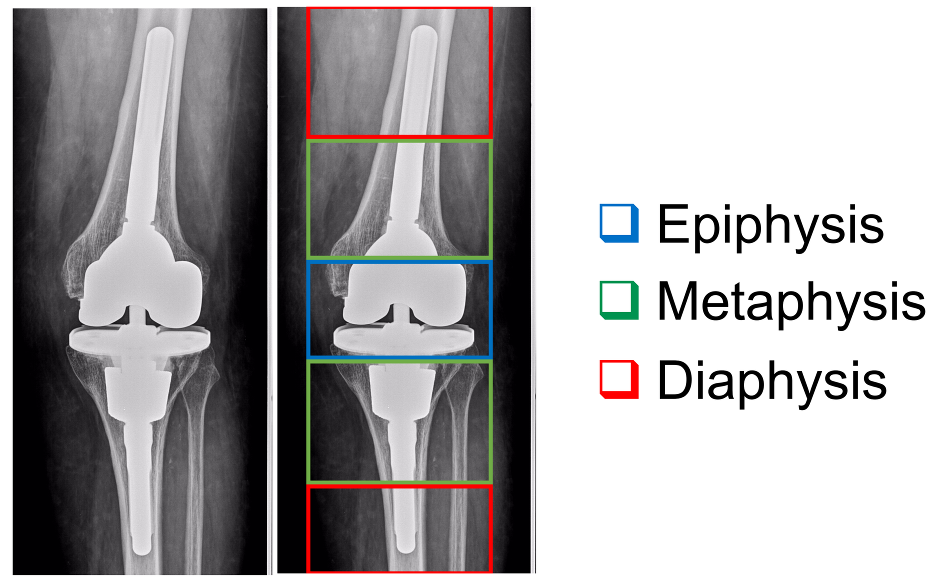
INTRODUCTION

- Revision total knee arthroplasty (rTKA) rate expected to increase
- Adequate fixation of the implant is a critical component to success[1]
- Zonal fixation



Deep Learning in Orthopedic Research

Classification Tasks
- Implant classification

Object Detection
- Fracture detection

Segmentation Tasks[2]
- Bony landmark annotation

PURPOSE

- **To develop a deep learning algorithm to delineate fixation zones automatically and accurately on postoperative radiographs**

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METHODS

1. Patients who underwent rTKA with postoperative radiographs were retrospectively included
2. Images split into a 6:2:2 ratio (141:47:47 images) for training, validation, and independent testing
3. A U-Net model was trained using transfer learning and data augmentation for landmark identification related to rTKA fixation zones (femoral component, tibial component, fibula, femur, tibia), and optimized on the multi-class dice segmentation coefficient (DSC)
4. Model predictions processed to automate epiphyseal, metaphyseal, and diaphyseal revision zones on postoperative images.
5. Zone spatial agreement between the algorithm and a fellowship-trained surgeon was assessed using the DSC (0.0 = no agreement, 1.0 = perfect agreement).

FIGURE 1

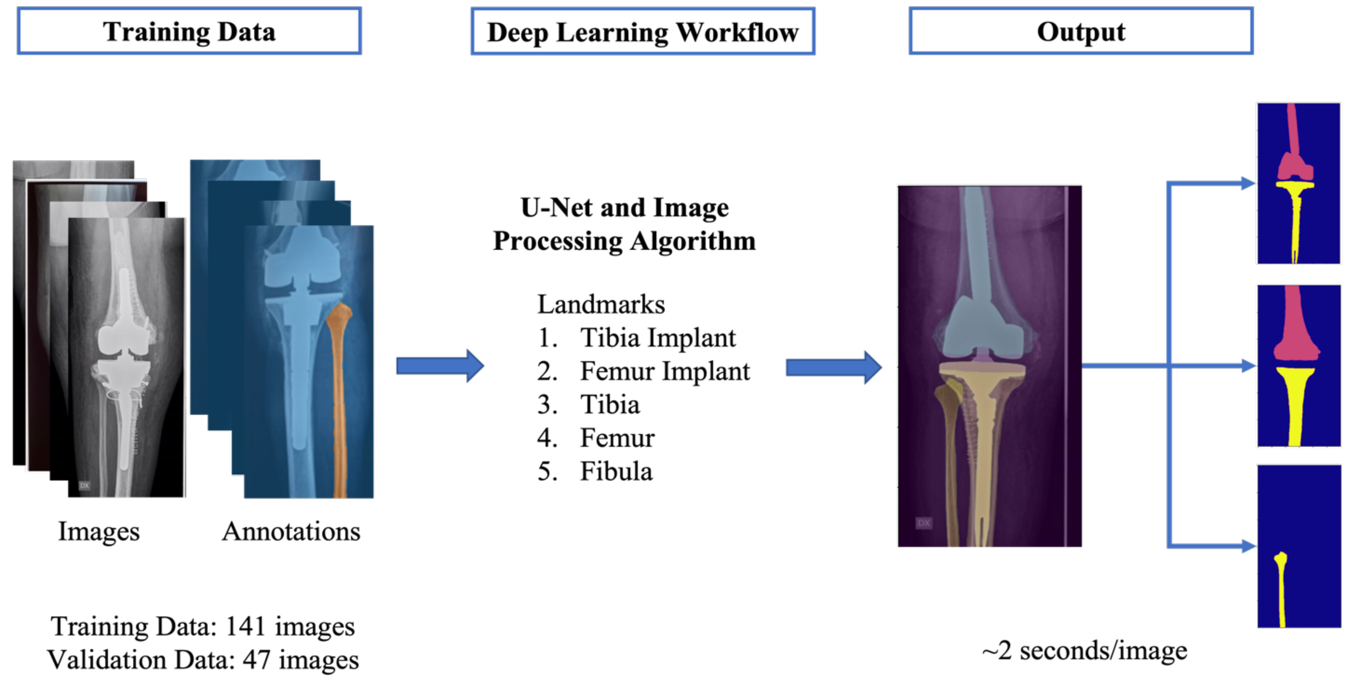

Figure 1: Creation of deep learning algorithm for landmark identification

FIGURE 2

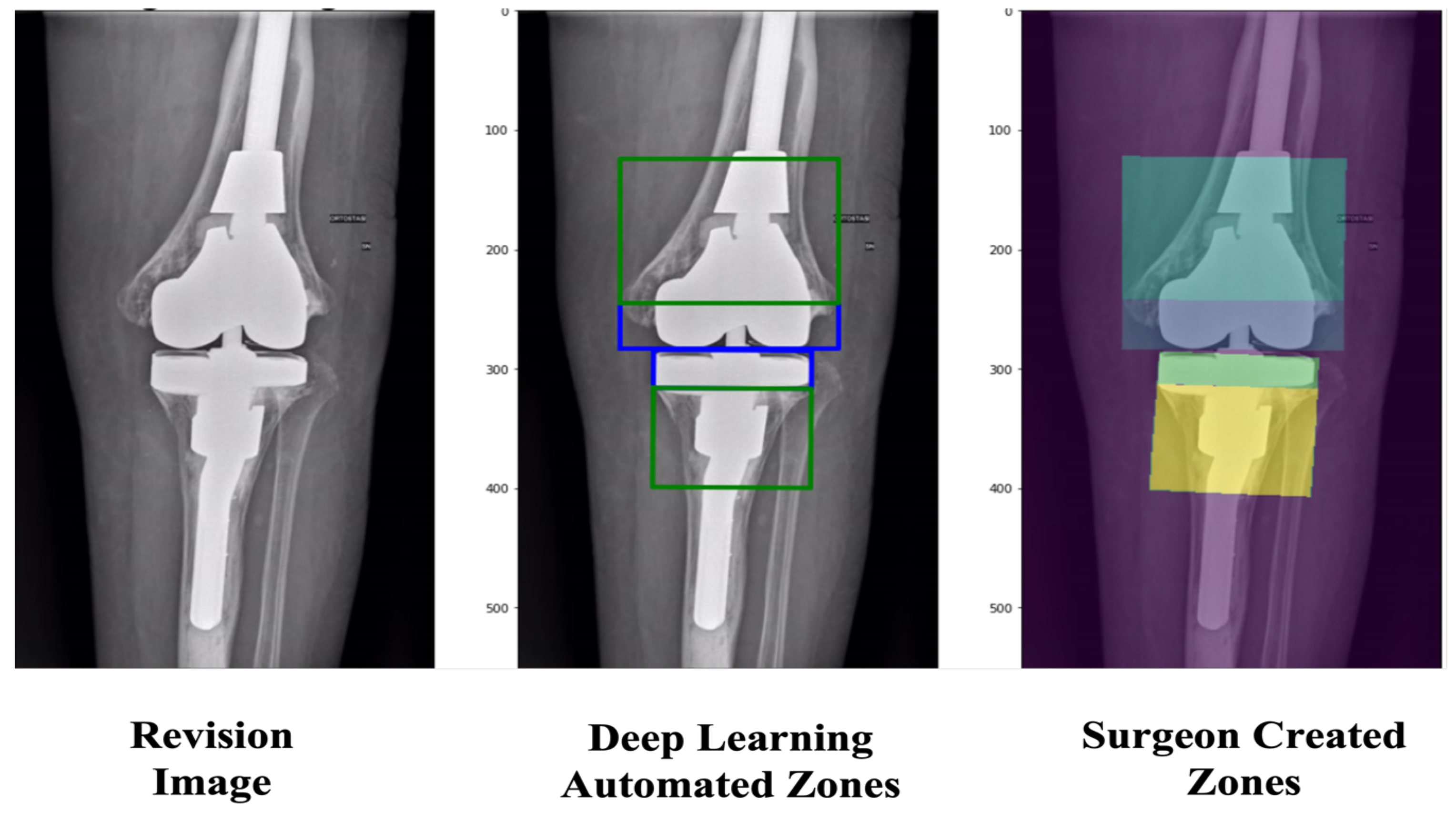

Figure 2: Example of deep learning automated revision zones from predicted landmarks

FIGURE 3

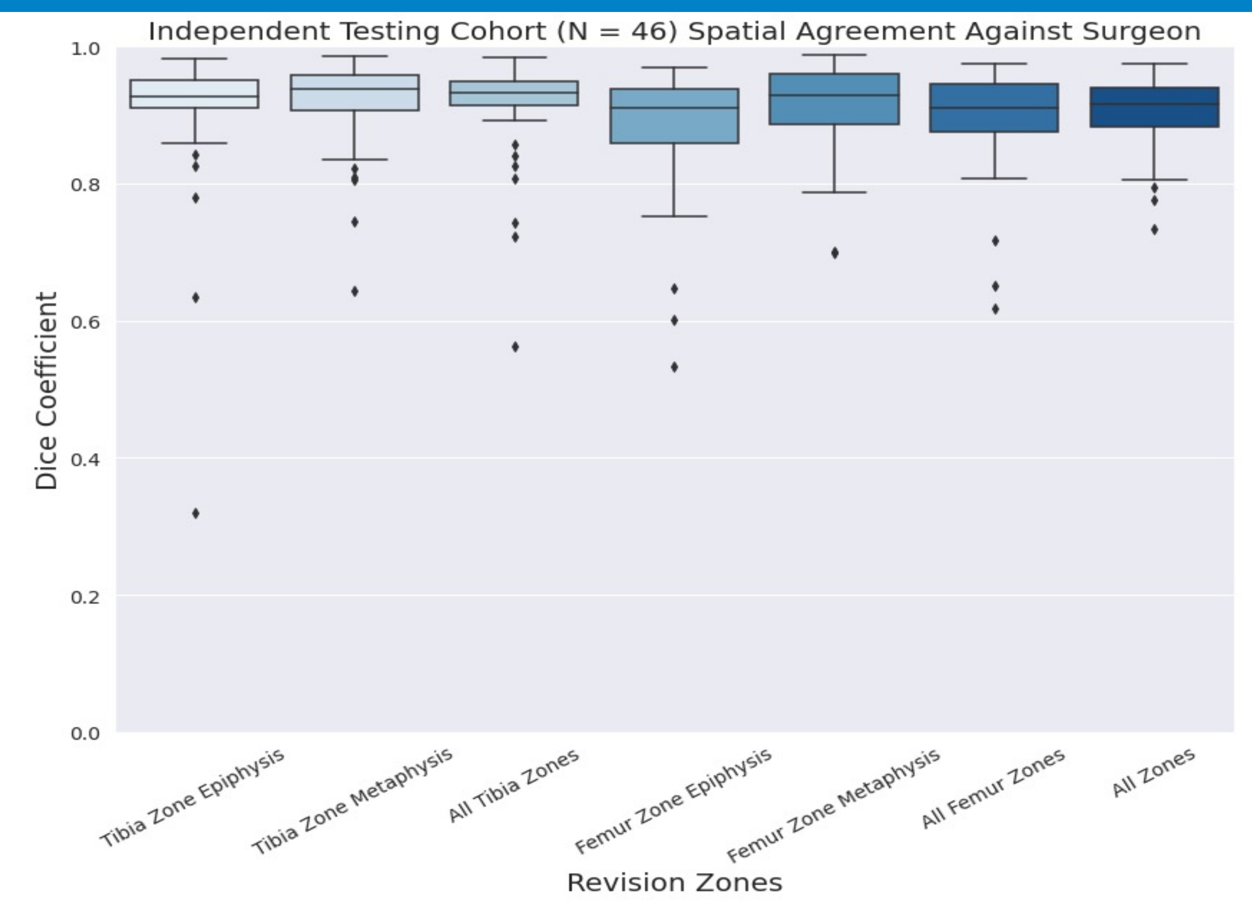

Figure 3: Spatial agreement between deep learning automation and surgeon measurements on independent testing cohort. Spatial agreement measured using the dice coefficient.

RESULTS

- The U-Net had a DSC of 0.95 – 0.98 for landmark segmentation relevant to revisions zones
- The algorithm failed to find landmarks necessary for zone automation in only 1 image (2%)
- On the testing cohort, the model was able to delineate all zones at a rate of 8 seconds per image (6.4 minutes for 46 patients)
- The DSC between the model and surgeon:
  - 0.89 ± 0.08 (IQR: 0.88-0.94) for femoral zones
  - 0.91 ± 0.08 (IQR: 0.91-0.95) for tibial zones
  - 0.90 ± 0.05 (IQR: 0.88-0.94) for all zones

CONCLUSIONS

1. **High accuracy in zone creation on rTKA radiographs using a deep learning model**
2. **Rapid production of zones images (~2 seconds)**
3. **External validation with HSS data**

REFERENCES

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2. Jang SJ, Kunze KN, Vigdorchik JM, Jerabek SA, Mayman DJ, Sculco PK. John Charnley Award: Deep Learning Prediction of Hip Joint Center on Standard Pelvis Radiographs. *J Arthroplasty*. 2022;37(7S):S400-S407.e1. doi:10.1016/j.arth.2022.03.033