An augmented reality based simple navigation system for pelvic tumor resection

Hyunseok Choi, Yeongkyoon Park, Hwanseong Cho, Jaesung Hong
Ph.D Candidate, Department of Robotics Engineering, DGIST, Korea
MD, Department of Orthopedic Surgery, Seoul National University Bundang Hospital, Korea
MD, Department of Orthopedic Surgery, Seoul National University Bundang Hospital, Korea
Ph.D, Department of Robotics Engineering, DGIST, Korea
Choihs85@dgist.ac.kr, naeda09@naver.com, mdchs111@snu.ac.kr, Jhong@dgist.ac.kr

Abstract: The navigation for bone tumor resection have been introduced to orthopedic oncology to achieve adequate resection margins. However, most navigations still expensive and uncomfortable due to its external optical tracking system (OTS). Therefore, we developed a simple navigation system which does not use external OTS to guide a tumor resection. The proposed system is based on augmented reality (AR) which give more intuitive visualized information for resection margin. To evaluate the proposed method, we performed animal study using 36 pig pelvises and verified its accuracy and effectiveness.

1. Introduction

Resection of pelvic tumor is one of major surgical challenge because of its complex structure and adjacent critical organs such as blood vessels and nerves [1]. In addition, safety margins should be achieved to conserve function of pelvic after surgery. Over the last decade, various navigation systems have been applied to bone tumor resection [2]. Most of them are accurate but unintuitive and complex to use intraoperative. Therefore, we developed a simple navigation for bone tumor resection which is AR based intuitive system.

2. Method

For cost effective and uncomplicated system, the external OTS was not used. Instead, an embedded camera on a tablet PC was used to track patient and tools as well as for AR visualization. Compared with the external OTS, conventional mono-camera tracking system is less accurate and have a narrow field of view. To compensate the limitations, multi-faced reference markers were used. To track the marker with mono-camera, perspective n-points algorithm was used. From this method, we can estimate a pose relationship between camera and marker. The marker was rigidly fixed on the patient body, then the patient to image registration was performed by using paired point registration method. For the registration, four to six anatomical and artificial land markers were used. From the registration and estimated camera pose information, we could compute the relationship between camera and patient. By computing the relationship continuously, the segmented virtual tumors can be overlaid on the patient in real-time. In the proposed system, the tumor can be observed in any direction due to the multi-faced reference marker.

The safety margin for tumor resection was displayed as a shape of contour, which is described in Fig.1. This visualization was processed as follow. When the camera was positioned in front of target region, the overlaid tumor was projected on the virtual 2D image plane. Then the projected tumor image was binarized to apply morphological filter. Dilation filter was used to extend an outline of tumor image, thus safety margin was determined by kernel size of the filter. From the dilated tumor image, contour was extracted that represents safety margin. This contour was updated according to the pose of camera in real-time.

To verify the effectiveness of proposed system, we performed an animal study. The 36 pig pelvises were used to simulate the bone tumor. A cortical window was made on the iliac and bone cement was inserted. Among the 36 pig pelvises, 18 were resected by conventional method and other 18 pelvises were resected by aid of proposed navigation system. Both of the experiments were performed by expert orthopedic oncologists.

3. Results

The bone tumor resection was simulated with 10 millimeter (mm) resection having proximal and distal margins to bone cement. We represent all results in Fig. 2. The mean value of safety margin in conventional method was 12.28 mm and AR method was 10.26 mm. Two sample t-test also performed to compare two groups, the p-value was less than 0.05 that represent two groups are significantly different.

4. Conclusion

The simple and intuitive navigation system was developed to guide a bone tumor resection. In addition, external OTS was not used in this system. Therefore, the proposed system can be used to the portable devices with cost effectively. The visualization of safety margin is also intuitive, surgeons could intuitively decide the position where the resection should be performed. Although the proposed method was not accurate than external OTS, it was sufficient for bone tumor resection.

References

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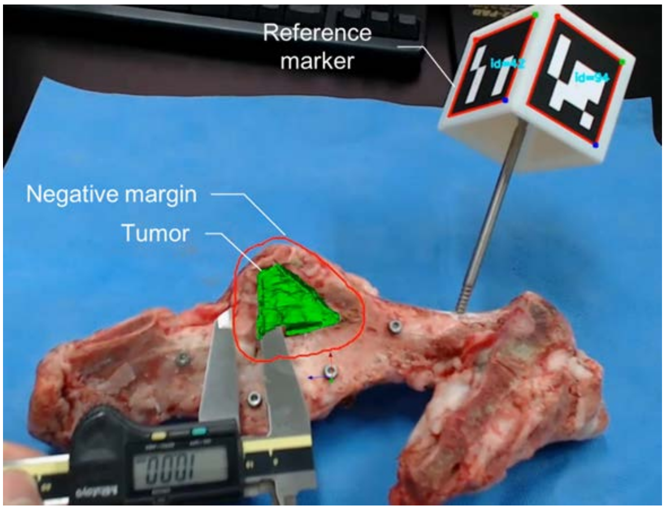

Fig. 1. The bone tumor navigation scene. Safety margin is displayed as a contour with 10 mm intact.

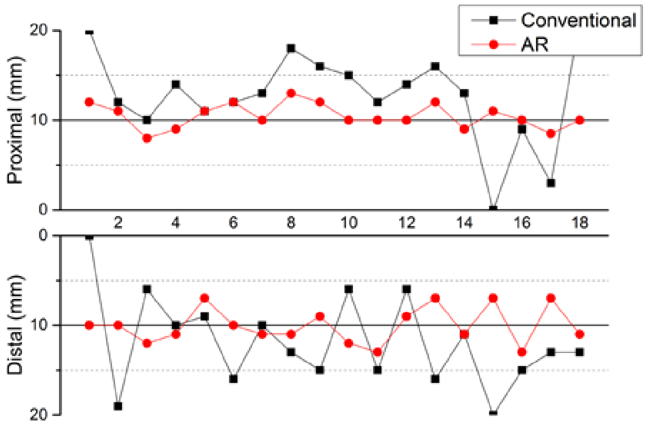

Fig. 2. The results of tumor resection from the conventional method and AR intervention. Some trials of conventional method were exceed the tolerance of safety margin (±5 mm), but the all results of the AR guidance were within the tolerance.