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ORIGINAL ARTICLE

Three-dimensional printing technique assisted cognitive fusion in targeted prostate biopsy

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Abstract *Objective:* To explore the effect of 3-dimensional (3D) printing-assisted cognitive fusion on improvement of the positive rate in prostate biopsy.
Methods: From August to December 2014, 16 patients with suspected prostatic lesions detected by multiparametric magnetic resonance imaging (MRI) were included. Targeted prostate biopsy was performed with the use of prostate 3D reconstruction modeling, computer-simulated biopsy, 3D printing, and cognitive fusion biopsy. All patients had received 3.0 T multiparametric MRI before biopsy. The DICOM MRI files were imported to medical imaging processing software for 3D reconstruction modeling to generate a printable .stl file for 3D printing with use of transparent resin as raw material. We further performed a targeted 2- to 3-core biopsy at suspected lesions spotted on MRI.
Results: For the 16 patients in the present study, 3D modeling with cognitive fusion-based targeted biopsy was successfully performed. For a single patient, 1–2 lesions (average: 1.1 lesions) were discovered, followed by 2–6 cores (average: 2.4 cores) added as targeted biopsy. Systematic biopsies accounted for 192 cores in total, with a positive rate of 22.4%; targeted biopsies accounted for 39 cores in total, with a positive rate of 46.2%. Among these cases, 10 patients (62.5%) were diagnosed with prostate adenocarcinoma, in which seven were discovered by both systematic and targeted biopsy, one was diagnosed by systematic biopsy only, and two were diagnosed by targeted biopsy only. For systematic biopsy, Gleason score ranged from 6 to 8 (average: 7), while that for targeted biopsy ranged from 6 to 9 (average: 7.67). Among the seven patients that were diagnosed by both systematic and targeted biopsy, three (42.8%) were reported with a higher Gleason score in targeted therapy than in systematic biopsy.

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Conclusion: 3D printing-assisted cognitive fusion technique markedly promoted positive rate in prostate biopsy, and reduced missed detection in high-risk prostate cancer.

1. Introduction

Transrectal ultrasound (TRUS) guided prostate biopsy is the first choice in the diagnosis of prostate cancer [1]. However, the traditional method has difficulty in avoiding missed diagnosis, for as high as 22%—47% of prostate cancer are missed in the initial biopsy [2]. The standard TRUS guided prostate biopsy is mainly for sampling in the peripheral zone where the incidence of cancer is high, but this conventional approach is poor in sampling cancers at the anterior, midline, and apex of the prostate, leading to underdiagnosis of clinically significant diseases [3]. Magnetic resonance imaging (MRI) has higher sensitivity in finding clinically significant prostate cancer [4]. Functional MRI technique as dynamic contrast-enhancement (DCE) and diffusion weighted imaging (DWI) may provide more accurate space orientation on the basis of qualitative diagnosis. It has now become an important problem regarding the use of image positioning to guide prostate biopsy so as to effectively improve the biopsy positive rate in the early diagnosis of prostate cancer. MRI-TRUS fusion targeted biopsy and MRI-guided targeted biopsy are effective approaches to improve biopsy positive rate and avoid missed diagnosis of prostate cancer [5,6], but both have higher requirement for hardware facilities, and need complicated skills in operation; therefore, it is rather difficult to apply these methods in conventional examination.

Currently, 3-dimensional (3D) printing technique is fast developing and has infiltrated into multiple industries including healthcare industry. Now its application in medical field is mainly in implant design, surgery simulation, skill training and others. There has not been much report from urinary surgery in this regard. This study explores 3D printing technique assisting cognitive fusion for design of prostate biopsy regimen, and evaluates its feasibility and efficacy in improvement of positive rate of prostate biopsy.

2. Patients and methods

2.1. Patients

This prospective study was conducted in the Changhai Hospital Affiliated to Second Military Medical University (Shanghai, China). The code of ethics was reviewed by the Institutional Review Board of Changhai Hospital and approval was obtained. Informed consents were obtained from patients eligible for this study, and any potential harms and benefits regarding to the study were elaborated. Study enrollment began in 2014.

2.2. Multi-parameter MRI examination

All patients had received 3.0 T multiparametric MRI (Siemens Magnetom Skyra, Germany) before biopsy. The scan sequence included T1 weighted, T2 weighted, DCE and DWI. Two radiologists identified and located lesions suspicious for cancer according to the MRI sequences (Fig. 1A). Both radiologists were blinded to pre-imaging serum prostate specific antigen (PSA) values and digital rectal examination (DRE) status.

2.3. 3D reconstruction and 3D printing

Digital Imaging and Communications in Medicine (DICOM) format file of MRI was introduced into medical image processing software accordingly. Prostate and tumor images were introduced for 3D model reconstruction and smoothly processed to generate printable .stl format files (Fig. 1B,C). By means of SLA, RS-450, 3D printer, the *.stl* files were printed in accordance with a thickness of 0.1 mm. The printing material was transparent resin (Fig. 1D).

2.4. Systematic prostate biopsy

All patients received 12-core systematic prostate biopsy under TRUS guidance. The 12-core biopsy was performed on the basis of the traditional 6-core biopsy by adding three cores on both sides of the lateral peripheral zones.

2.5. Targeted biopsy under 3D printing assisted cognitive fusion

The suspected lesions found by multi-parametric MRI further underwent a targeted 2—3-core biopsy. Before biopsy, the location of the suspected focus in the prostate was determined according to the 3D reconstruction data, followed by computer simulation 12-needle systematic biopsy performed (Fig. 2A) to estimate whether the suspected focus could be detected in the course of biopsy. If the suspected focus was in the anterior, midline, and apex, because of the limitations of biopsy angle or biopsy depth, systematic biopsy might not be able to take samples. Then computer simulation of targeted biopsy procedures (Fig. 2B) should be done to select biopsy sections, needling angles and needling depth at triggering.

3. Results

From August to December, 2014, 16 patients (median age 64 years) successfully underwent 3D modeling with cognitive fusion-based targeted biopsy. Patient and biopsy