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Case Report

3D printed model to assist endovascular prostate artery embolization for benign prostatic hyperplasia☆

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ABSTRACT

With the growth and ease of 3D printing accessibility, the medical community has begun to adopt it in various ways. Modeling of prostatic arteries for embolization is an application that has yet to be fully explored. We present a case where a patient specific 3D-printed model was used as a reference during prostate artery embolization for a 70-year-old male with obstructive benign prostatic hyperplasia refractory to medical treatment. The prostate arteries were segmented from preoperative contrast enhanced computed tomography using 3D Slicer software and printed on a FormLabs Form2 resin printer. The models were then used for operative planning for the embolization of both right and left prostate arteries. The procedure was a success without complications and the patient returned 1 month later with significantly improved symptoms. Additionally, interventionists found the model to be helpful in selecting approach for arterial embolization.

Case report

Benign prostatic hyperplasia (BPH) affects as many as 50% of men older than 50, and 90% of men older than 80 [1]. The main indication for procedural intervention in BPH is lower urinary tract obstruction that is refractory to medication or when medication is not tolerated. Procedural options for BPH include transurethral resection of the prostate, prostatectomy, and endovascular prostate artery embolism (PAE) with PAE being the least invasive option. As such, PAE proven to be a reliable treatment modality when medication fails.

With the growth and ease of 3D printing accessibility, the medical community has begun to adopt it in various ways [2–4]. In the surgical community, anatomic models of patient anatomy have been shown to consistently increase confidence in clinical decision making and preprocedure planning [2,4]. Selection of an adequately distal branch of the prostate artery for embolization during PAE is often tedious given the vast anatomic variation and tortuosity of its course. This suggests that PAE may be an excellent setting for the use of patient-specific 3D-printed anatomic models [5,6] and is

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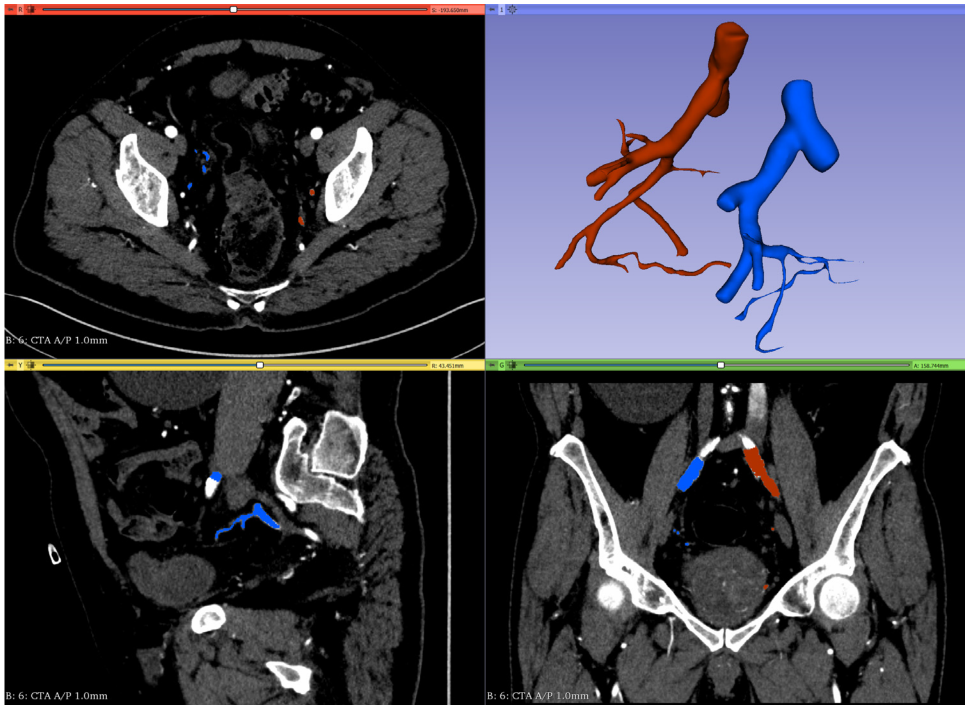

Fig. 1 – Screen capture of Slicer Software demonstrating axial, coronal, and sagittal views of patient's computed tomography (CT) imaging with superimposed segmentation of left (blue) and right (red) prostate arteries. Top right panel shows rendered 3D image of left (blue) and right (red) prostate arteries. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.).

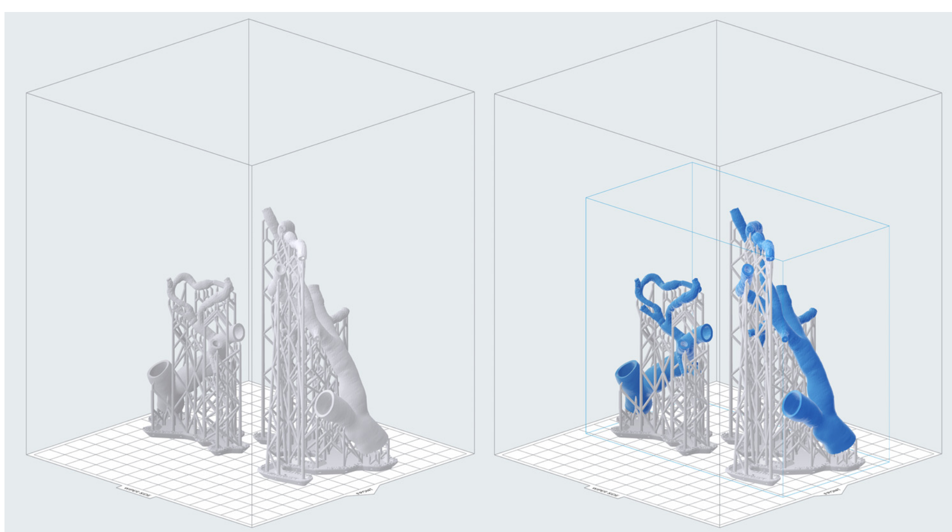

Fig. 2 – Screen capture of PreForm software used to prepare the models for Form2 resin printer. On the right, the models themselves are highlighted in blue and gray areas denote support materials required for resin printing viability. On the left, the model is shown as it is printed without supports removed. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.).

one such avenue that has yet to be extensively explored. We present a case in which a patient-specific 3D-printed model was utilized for preprocedure and intraoperative reference by interventional radiologists during PAE.

A 70-year-old man presents with large gland BPH and urinary retention. In addition, he has a past medical history of primary hypertension and atherosclerosis. He is status-post cystolitholapaxy and cystoscopy 2 months prior. He requires intermittent self-catheterization to relieve his urinary retention despite attempts at medical management involving finasteride and tamsulosin. He was scheduled to undergo PAE with interventional radiology after discussion with his urologist.

Fig. 3 – Anterior view of prostate artery models from the coronal plane. Left prostate artery on the right, right prostate artery on the left.

Preoperative contrast-enhanced computed tomography was obtained as part of standard care. The left and right prostate arteries were identified, subsequently segmented in 3D Slicer software, processed in Meshmixer, and exported to PreForm slicer for printing on a Formlabs Form2 SLA resin printer (Figs. 1 and 2). The printed models of the patient anatomy (Fig. 3) were given to the interventional radiologist the week before the procedure to assist with assessment of patient anatomy, viability of PAE, and planning the approach to vessel selection. The right common femoral artery was accessed followed by left prostate artery selection utilizing the 3D-printed model to aid in branch selection. After contrast injection confirmation of the appropriate position, the branch was embolized with 300-500 micron Embosphere particles. The microcatheter was withdrawn and arteriogram performed to ensure embolic effect. Next, the right prostate artery was catheterized via the right internal iliac artery with assistance of the relevant 3D-printed model as a visual aid. In a similar fashion 300-500 micron Embospheres were utilized to embolize the right prostate artery, with pre and post arteriography. No immediate complications occurred, and the patient was discharged in satisfactory condition with a successful bilateral prostate artery embolization. He returned to clinic 1 month later with significantly improved clinical status and endorsed overall improvement in quality of life.

Discussion

A patient-specific 3D-printed model of the patient's anatomy was created to aid in the planning and performance of endovascular PAE. The model was used to ensure that the appropriate vessels were accessible in an efficient and safe manor.

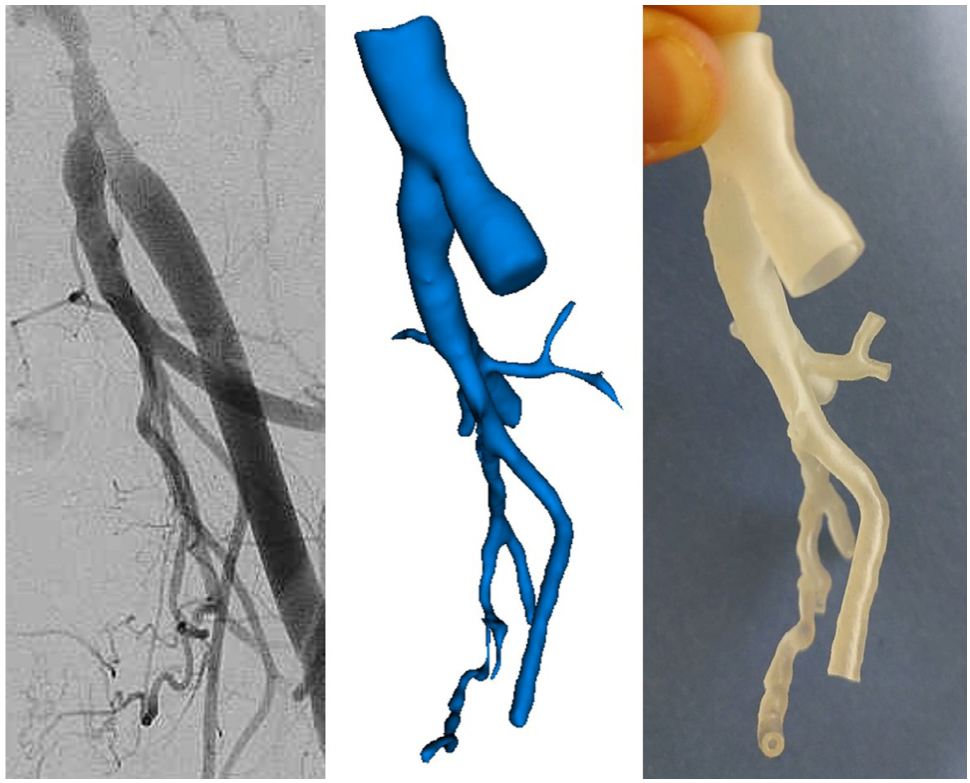

Fig. 4 – Figure comparing left prostate artery fluoroscopy (left), segmented model in software (middle), and 3D-printed model (right). Figure validates accuracy of the model with intraprocedure fluoroscopy.

Secondarily, the model was shown to the patient and trainees as an educational tool to demonstrate anatomy and challenges of the procedure. Intraoperatively, the model was used as an adjunct to imaging to confirm the trajectory of catheters. The model allowed for a 3D visuospatial representation of standard AP fluoroscopy (Fig. 4). This allowed the interventionist to have more confidence during the procedure. The model was also a useful learning tool for the patient and students.

A larger study may be conducted that quantifies the effect of these models on procedure time, radiation dose, and technical success of PAE. Additionally, models may in the future be sterilized and taken into the operating room for interventionist to examine intraoperatively.

Patient consent

The patient was consented and this manuscript has preapproval from the institution's IRB.

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