Preoperative Evaluation for Complex Female Genital Tract Malformation Using Three-dimensional Printing Technology

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A 33-year-old woman, gravida 1, para 0, came to the hospital with the chief complaint of severe dysmenorrhea and infertility. Her menstrual cycle was regular, bleeding moderately for 3–5 days with an interval of 30 days. She was diagnosed with ectopic pregnancy and received the left salpingectomy in September 2014. Intraoperative exploration showed a slightly enlarged retroverted uterus with a wide fundus and a normal right fallopian tube. As a further examination of infertility, hysterosalpingography was done in January 2016, which showed a unicornuate uterus (left) with an obstructed unilateral fallopian tube. She was referred to the Department of Obstetrics and Gynecology at Peking Union Medical College Hospital in February 2016. Her basic body temperature showed biphasic pattern. The sperm test of her husband was normal. Physical examination indicated two vaginal orifices in the vestibule, with a vertical septate lying in between. The left lateral vaginal lumen could be easily expanded and speculated, and a normal cervix was seen at its top. In contrast, the cervix was unable to be seen through the right lateral vaginal lumen, which was narrow and difficult to be exposed or inspected. Pelvic ultrasound scan showed that the uterus was 4.7 cm × 6.0 cm × 3.6 cm in size, along with the Y-shaped endometrium of 0.8 cm in thickness, and a normal echo in the muscular layer. No abnormalities were found at the bilateral adnexa areas or pelvic cavity. Besides, the bilateral renal areas and ureters were found normal in the ultrasound scan as well.

We performed the thin-layer pelvic magnetic resonance imaging (MRI) with a thickness of 1 mm. According to DICOM data, the three-dimensional (3D) anatomical image of the patient's uterus, cervix, and vagina was reconstructed using 3D software [Figure 1a and 1b]. The 3D model printing of the patient's genital tract was completed using light-cured SLA Technology (Prismlab RP400, Prismlab, China) with light-sensitive resin material [Figure 1c].

The above preoperative assessment (including the physical examination and 3D printing technique) revealed that the patient had a single uterine body which was completely divided into the left and right cavities from inside, despite no fundus depression from outside. The uterus was then connected to the vagina with two complete separated cervical channels. In addition, a complete longitudinal septate was also identified in the vagina. Therefore, the comprehensive preoperative assessment proposed the diagnosis of complete septate uterus (Va, rAFS classification, 1998) complicated with double cervix and double vagina, which was a rare condition in complex female genital tract malformation. Similar cases have been previously reported in the literature.[1-4]

This patient received the hysteroscopic and laparoscopic surgery in June 2016 in the Department of Obstetrics and Gynecology at Peking Union Medical College Hospital. The intraoperative findings confirmed the diagnosis of complete septate uterus with double cervix and double vagina, which was completely consistent with the preoperative evaluation.

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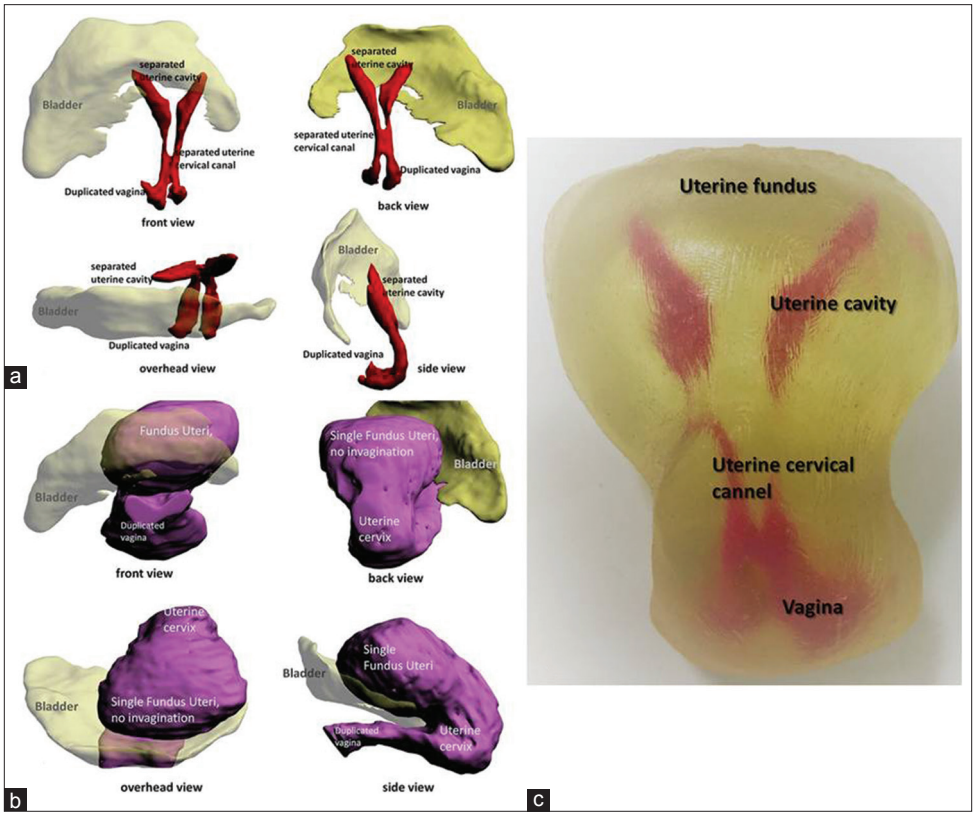

Figure 1: Three-dimensional image model reconstructed for the patient's reproductive tract. Three-dimensional image representing the patient's uterine cavity, cervical canal, and vaginal internal cavity, showing two completely separate uterine cavities, two completely separate cervical canals, and two isolated vaginas (a). Three-dimensional image representing the external contours of the patient's uterus, cervix, and vagina, showing single uterine fundus and double vagina (b). Three-dimensional printing model of the patient who was diagnosed with complete septate uterus with double cervix and double vagina, which is a form of complex genital tract malformations (c).

Finally, the patient received the surgery of laparoscopic lysis of pelvic adhesions, hydrotubation, hysteroscopic resection of uterine septate, and resection of vaginal septate. Six months after the surgery, the patient managed to conceive naturally in January 2017. She is now receiving regular antenatal examinations and the fetus is growing well as expected.

Preoperative diagnosis is particularly difficult for complex genital tracts, especially for those with combinations of multiple urinary system malformations. Currently, the commonly used methods are gynecological physical examinations, ultrasound scan, and MRI if necessary. However, these methods are often unable to describe the sites, types, and coexisting disorders accurately.

In this case, we obtained data from the thin-layer MRI imaging technique (layer thickness of 1 mm) and processed it in the 3D software to mold the 3D reconstruction models for the patient's reproductive organs and genital tract malformations. We adopted resin as the material in printing the 3D simulative model of the uterus, cervix, and vagina. As a result, the 2D MRI imaging information was converted into the intuitive 3D objects, which might be helpful for clinicians to make preoperative diagnosis and for patients to understand their organ abnormalities during the presurgical discussion. It was also valuable in educating medical students the basic anatomy of complex genital tract malformations.

In this case of female genital organ abnormality, the 3D printing model was satisfactorily consistent with the intraoperative findings. In summary, there are several tips in 3D printing technique based on our own experience. First of all, to meet the needs of 3D digital reconstruction, accurate imaging data are required. For example, thin-layer MRI or computed tomography (CT) is much more suitable than regular MRI or CT. Moreover, MRI is superior to CT in evaluating female genital tract disorders, mainly because of its higher imaging resolution in soft tissues. Furthermore, MRI can display the views that show the human body at any angle, while CT can only show a cross-sectional layer perpendicular to the long axis of the body.[5] According to the above reasons, we chose thin-layer MRI technology as the source of imaging data in this case. In the preexperiment, we explored the different layers of thickness and their image qualities, discovering that MRI scan with 1 mm layer thickness could produce the most satisfying 3D images of the reproductive organs. In addition, the cooperation between the gynecologists and the experienced radiologists is very essential in processing the MRI data, molding a high-quality 3D image, and in building the 3D printing organ model which represents the anatomical structure as true to life as possible. In this study, photosensitive resin was used as the raw material in 3D printing, providing a transparent-to-translucent appearance in the end product and

clearly reflecting both the external contours and the internal lumen of the genital tract.

In conclusion, our preliminary attempt suggested that 3D printing technology based on thin-layer MRI might become a new technique in the noninvasive diagnosis for the complex female genital tract malformations. However, more in-depth researches are required in the future to widen the application range of this technology, and to improve its technique as well as the cost-effectiveness in treating gynecological conditions.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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