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INTRA-OPERATIVE REAL-TIME VIRTUAL MRI GUIDANCE TO SECURE THE NEEDLE PENETRATION FOR INSERTION OF THE MESH ARMS DURING TENSION FREE VAGINAL MESH PROCEDURES

Hypothesis / aims of study

The tension-free vaginal mesh (TVM) procedure (1) has been developed, to be increasingly applied to almost all types of pelvic organ prolapse (POP). However, the TVM procedures involve the finger-guided blinded needle penetration for insertion of mesh arms through the ligaments. Therefore, potential secure anatomical navigation for needle penetration has been required for achieving precise needle placement through the targeted ligaments as well as avoiding complications such as bleeding, nerve injury, bladder injury, ureteral injurey, and rectal injury. Magnetic resonance imaging (MRI) and ultrasound (US) imaging are recognized to provide a diagnostic visualization of POP and the vital anatomy along the needle tracts such as neurovascular bundles, bladder, ureter, and rectum (2). Such imaging also potentially demonstrates the success of surgical therapy (2). To our knowledge, there was no reports regards intra-operative use of MRI for surgical navigation during TVM procedure. Herein, we report a novel intra-operative navigation system to provide real-time visualization of MRI-tomograms in order to navigate the needle insertion during TVM surgery. Our new navigation system could intra-operatively, real-timely provide the any angled required tomograms out of 3T-MRI volume data, which are the same tomograms with both ventral and vertical planes of the surgeon's index-finger-axis, simultaneously. The fundamental software of the navigation system is arranged from our initially applied navigation system, named by Real-time Virtual Sonography, which is the image fusion system of real-time US with pre-operative MRI (3).

Study design, materials and methods

Our developed navigation system consists of (i) magnetic field generator, which is placed near the patient, (ii) US machine, (iii) magnetic sensor attached US probe, (iv) magnetic sensor attachment for surgeon's index finger, (v) magnetic position sensor unit (mini-BIRD, Ascension, U.S.A.) and (vi) computer workstation and display. MRI of the pelvis was obtained in advance, and the MRI volume data were transferred to the computer workstation by CD with DICOM data. A magnetic positioning sensor unit is connected to the workstation to obtain information on the spatial position of the US probe and/or surgeon's index-finger-attachment. When the US diagnostic equipment starts scanning and US cross-sectional images are displayed on the monitor, registration of the intra-operative surgical field is performed according to real-time US images and then, the software can reconstruct the fused MRI tomogram, which is synchronized with real-time US. After such procedures of registration between the real surgical field and the pre-operative MRI spatial filed by US/MRI fused imaging, our developed navigation system can demonstrate any angled reconstructed tomograms of MRI, which correspond with both ventral and vertical planes of the surgeon's index-finger-axis. Since the magnetic sensor attachment for surgeon's index finger is ring-shape, surgeon's tactile feedback on the index finger-tip remains, with image navigation function according to the finger-axis's directions by the software.

Results

3T thin sliced MRI successfully detected the tendinous arch of the pelvic fascia (ATFP) between the pubic bone (PB) and the ischial spine (IS) (Fig 1A). Using our intra-operative navigation system, when the surgeon manipulated the index finger with magnetic sensor attached, the searched MRI images of ATFP were demonstrated on the display (Fig 1B and 1C), sequentially and simultaneously, according to the movements of the surgeon's index finger. Similarly, our software could demonstrate the critical anatomical landmarks including not only ATFP, PB, and IS but also the ureter, obturator vessels, and the neurovascular bundles in the posterior pelvis, if certain function of pre-operative MRI could demonstrate them.

Interpretation of results

Our novel navigation system achieves navigation functions of not only the tactile sense of surgeon's index finger but also the simultaneous visualization of the reconstructed MRI tomograms to be same with both ventral and vertical planes of the surgeon's index-finger-axis. Combination of tactile feedback of surgeon's finger and the anatomical visualization according to the surgeon's index-finger-axis has a great potential to increase precision and safety of this surgery.

Concluding message

We developed a novel surgical navigation system to provide the intra-operative, real-time visualization of any angled required tomograms out of pre-operative 3T-MRI volume data, which are the same tomograms with both ventral and vertical planes of the surgeon's index-finger-axis. It potentially provides an updated, and hence more accurate map of the patient's anatomy in all phases during the surgery. This system seems to have possibility to shorten the learning curve on TVM procedures, and to secure plating of mesh, leading to low recurrence rate. The accumulated data to evaluate clinical usefulness of the navigation system is awaited.

A B C

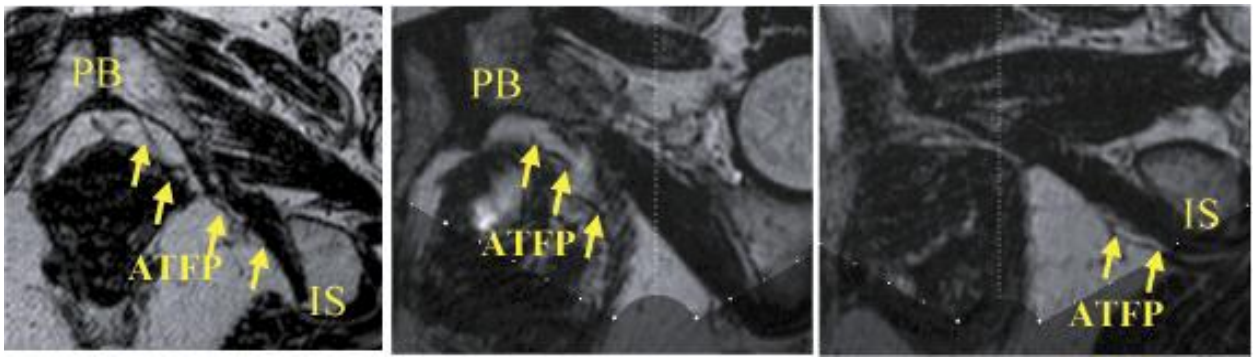

Figure A,B,C Pre-operative 3T MRI image (A, left) and the real-time intra-operative virtual MRI images (B, middle, and C, right) to visualize the AFTP in adjacent tomograms, which were reconstructed according to the surgeon's finger manipulations

References

1. Int Urogynecol J (2006) 17; 195-201
2. Eur. Radiol. (2004) 14; 1456-1464
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Was this study approved by an ethics committee?	**Yes**
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Was the Declaration of Helsinki followed?	**Yes**
Was informed consent obtained from the patients?	**Yes**