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TARGET-BASED 3D STRESS MRI MEASUREMENT TECHNIQUE FOR APICAL, PARAVAGINAL AND HIATAL CHANGES AFTER SURGERY FOR ANTERIOR/APICAL PROLAPSE

<u>Hypothesis / aims of study</u>
The anterior vaginal wall is the most common site of pelvic organ prolapse and the most frequent site of operative failure, comprising 72% of recurrences. So there is a need to re-appraise our current surgical strategies and assess the surgical goal achievement. Pelvic organ prolapse involves multiple structures which consist of three subsystems: vaginal wall, connective tissue attachment subsystem and levator ani muscle and hiatal subsystem. In our previous study[1], apical location, paravaginal location and hiatus size were found be highly correlated and are strong predictors of cystocele presence and size. The theoretical biomechanical model of prolapse[2] also reveal the interaction between three subsystems. We therefore hypothesis that the surgical alternation in one or more sites will have the impact on other support subsystems, however this impact has not yet been quantified and well understood. In this study we aim to develop the method to quantify the surgical induced changes in support subsystems by acquiring and quantifying pre- and post-op MRI spanning the full width of the pelvis during a maximal Valsalva (Stress MRI) to 1) precisely evaluate the subsystem surgical goal achievement, 2) better understand the interplay between support subsystems and the biomechanical consequence of the surgery.

<u>Study design, materials and methods</u>
The pre-op and post-op Stress MRI (3 month after surgery) were acquired for 5 women who underwent prolapse surgery. By acquiring sagittal images spanning the full width of the pelvis during a maximal Valsalva maneuver (stress MRI), the anterior vaginal wall shape and lateral margin locations were identified using an array of fiducial markers that established the x,y,z coordinates for a systematic series of locations from anterior fornix to the urethra vaginal junction (Figure 1, a&b). All of the landmarks were transformed from scanner coordinates to the modified 3D Pelvic Inclination Coordinate System (PICS) (Figure 1, c,d) using a custom Python-based software. This process allows for all structural locations to be compared in the same coordinate system, thereby compensating for differences in the subject’s location and pelvic inclination within the scanner. It is also aligned with the longitudinal body axis so that assessments can be made of “how high or low” (in a craniocaudal direction) a structure lies relative to the bony pelvis and the conceptual direction of gravity when standing. The anterior vaginal wall length was calculated from the anterior fornix to the distal end of the vagina at the external urethral meatus in the mid-sagittal plane by following the curve of the vaginal wall. The vaginal width was measured at five equally spaced sampling locations along the anterior vaginal wall from the anterior fornix (location 1) to the urethrovesical junction (location 5) (Figure 1, e). The vertical coordinates (z axis) of the anterior fornix were used to assess apical support. The paravaginal locations were assessed as vertical coordinates (z axis) of the lateral vaginal edge points at the five sampling locations from the anterior fornix to the urethrovesical junction (Figure 1f). Pre- and post- assessment of three subsystem were compared to their normal range defined by 30 normal controls from Chen 2016.

<u>Results</u>
The pre- and post- assessments of three subsystem were shown in Figure 2.

<u>Interpretation of results</u>
We are able to mark the fully prolapsed anterior vaginal wall and quantify support subsystem at various sites for both pre-op and post-op status. (Figure 1，2). This quantification scheme allows the objective, site specific evaluation of the surgical goal achievement in a bony landmark-based coordination system. The most frequent sites with insufficient support after surgery occur at the distal part of the vaginal as well as the hiatus. At the UVJ level, 80% of subjects’ vaginal wall are lower than the 25th percentile of normal after surgery. 40% hiatus are still outside the normal range despite the posterior repair.

The method also allows us to quantify the surgical induced change at the sites without direct surgical alternation. In all subjects, post-op the paravaginal location of the vaginal wall all have significant improvement (range from 19 -75mm) despite no paravaginal repair surgery performed. In patient A, without direct surgical alternation at the apex, her apical location recovered 2.7cm. These results provide the quantitative measurements demonstrating 1) abnormal paravaginal location (paravaginal defect) is the result of the prolapse 2) in some women, apical decent is also the result of prolapse.

<u>Concluding message</u>
We developed the method to quantify post-surgical changes in support subsystems based on pre and post stress MRI. This technique allows us to 1) evaluate to what extend post-surgical support subsystem being restored to normal anatomy and identify the subsystem with most frequent suboptimal results; 2) quantify the surgical induced change, especially in the subsystem without direct surgical alternation, allowing us to better understand the biomechanical consequence of the surgery.

Figure 1

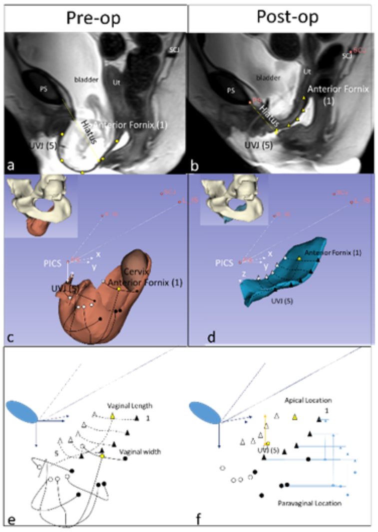
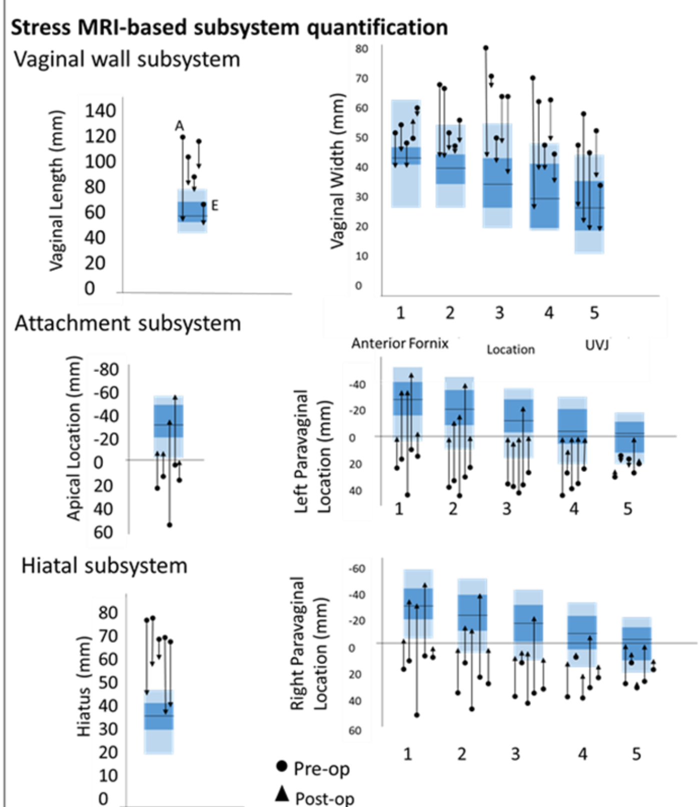


Figure 1 Measurement scheme. Fiducial markers identify the anterior vaginal wall on pre-op (a) and post-op(b) MRI. c and d shows the fiducial markers on the anterior vaginal wall model in PICS coordinate system. e shows the vaginal width and length measurement. f shows the apical and paravaginal location measurements.

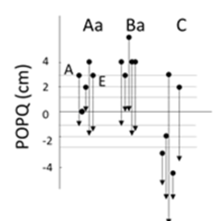
Figure 2 Five women with AVP who had pelvic prolapse surgery (surgical type and pre-op POPQ at the bottom). The parameters in vagina wall, attachment and hiatal subsystems were quantified for both pre-op (dots) and post-op (triangle). These measurements were plotted relative to the normal range shown as blue box with black line showing the median, dark blue indicating inner quartile range and light blue showing 10th -90th percentile range demonstrating the ability to assess surgical goal achievement at individual sites in three subsystems.

Figure 2



Surgical type and pre-op POPQ

Surgery	Patients				
	A	B	C	D	E
Vag Hysterectomy		X	X	X	X
Apical suspension			SSLS	USLS	USLS
Anterior Repair	X	X	X	X	X
Posterior Repair	X	X	X	X	X



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Disclosures

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