Quantification of Aging Effects on Urethral Morphology Using MRI

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Hypothesis & Aims of Study

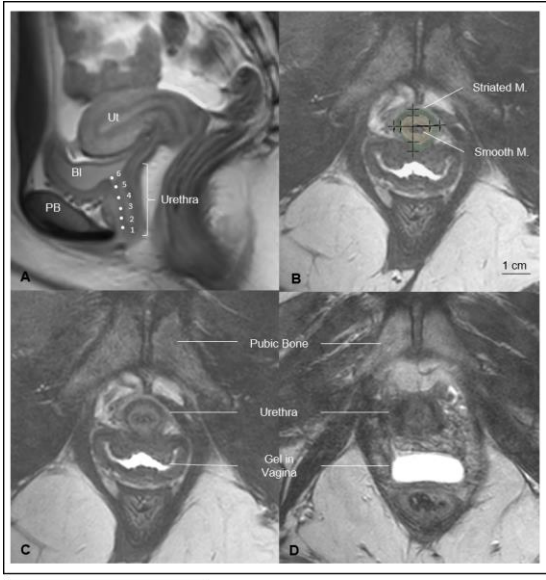
In histological studies of women, aging is associated with a **2% annual decrease in striated urethral sphincter muscle fibers** after age 50 due to fiber dropout within a dense connective tissue field [1]. It is unknown whether these changes can be quantified using MRI. Contrast to Noise Ratio (CNR) is a widely used measure of tissue characteristics in brain MRI, however its application to pelvic floor imaging has been limited [2].

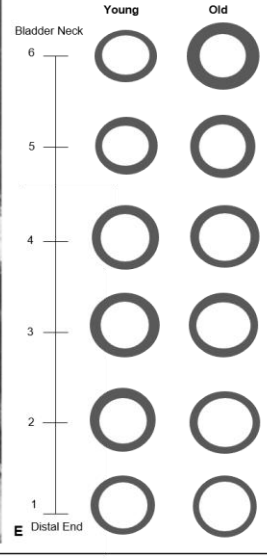
The **aims of this study** are to test the hypotheses that:

1. Striated external urethral sphincter thickness decreases with age.
2. Age-related changes in striated muscle characteristics can be assessed using MRI.

Table 1 – Demographics, tissue characteristics quantified as MRI Contrast to Noise Ratio (CNR) between Smooth and Striated Muscle and Urethral Striated Sphincter Length.

	Young	Older	p-value
Demographics			
Age, years	23.4 ± 2.3	74.4 ± 4.3	<.001
Body Mass Index, kg/m²	24.9 ± 2.5	28.1 ± 7.2	.26
Parity	0	0	--
Contrast to Noise Ratio (CNR) between Smooth and Striated Muscle	0.84 ± 0.26	0.56 ± 0.36	.09
Sphincter Length, mm	18.3 ± 4.1	20.7 ± 3.8	.24





F - External Striated Urethral Sphincter Thickness, mm

#	Transverse Direction			Anteroposterior Direction		
	Young	Older	p-value	Young	Older	p-value
6	3.8 ± 1.4	6.6 ± 2.8	.02	3.4 ± 0.8	5.9 ± 2.1	.01
5	4.0 ± 1.2	4.7 ± 1.9	.35	4.5 ± 1.1	4.8 ± 1.1	.66
4	4.7 ± 1.0	4.4 ± 1.5	.67	4.3 ± 0.9	4.1 ± 1.8	.71
3	5.3 ± 0.9	3.7 ± 1.3	.01	4.5 ± 0.9	4.5 ± 1.1	.93
2	4.6 ± 2.1	4.2 ± 1.8	.67	4.5 ± 1.5	3.7 ± 2.4	.40
1	4.0 ± 1.4	3.2 ± 1.9	.40	3.2 ± 1.9	3.0 ± 0.9	.85

Figure 1
A. Sagittal view of the six equidistant urethral cross-sections points; Pubic Bone: PB, Bladder: B, Uterus: Ut.
B. Anteroposterior and Transverse diameters of the striated muscle of the external urethral sphincter (short black lines).
C-D. Axial MRI showing the difference in tissue contrast and signaling between young (Panel C) and older (Panel D) nulliparous women.
E. Comparison of the average striated sphincter diameters and thickness at six equidistant points along the urethra.
F. External striated muscle sphincter thickness in mm. Data presented as mean ± SD, p-values determined using student's t-test and Bonferroni adjustment. $p < 0.004$ considered statistically significant.

Methods

This is a sub-analysis of **a pilot study on aging effects on the pelvic floor** comparing young (<40 yo) and older (≥70 yo) nulliparous women. All women underwent 3D Stress MRI using a 3-Tesla Ingenia scanner with 2 mm slice thickness.

All women had **normal pelvic support**, no demonstrable stress incontinence on examination and no history of surgery for prolapse or urinary incontinence.

The following **measurements** were manually made using 3D Slicer:

- Six equidistant points along the striated external urethral sphincter were identified (Figure 1A) and **measures of the inner** and **outer diameters in the transverse** and **anteroposterior** directions were made (Figure 1B).
- **Striated urethral thickness, defined** as the difference between the inner and outer diameters (Figure 1B).
- **Striated urethral sphincter length**, measured from point 1 to point 6.
- **The contrast-to-noise ratio (CNR)** of urethra sphincter muscle layers quantified using a contrast noise ratio (CNR) [2], where μ is the mean and σ the standard deviation.

$$CNR = \frac{|\mu_{striated\ muscle} - \mu_{smooth\ muscle}|}{\sigma_{striated\ \&\ smooth\ muscle}}$$

Results

- **18 women were included**, 9 young and 9 older (Table 1).
- **Striated urethral thickness did not significantly differ between groups** (Figure 1 F). However, most thickness measures were **larger in the younger group.**
- **Striated urethral sphincter length was similar between groups** (Table 1).
- **MRI signal CNR** is **non-significantly** higher in the younger women (p=.09) (Table 1).
- Post-hoc power analysis showed 47% power to detect a difference between groups with $\alpha = 0.05$.

Interpretation of results & Conclusion

Striated urethral sphincter thickness is **not** significantly **different between young and older** nulliparous women.

Age-related changes in **tissue characteristics** of the urethral sphincter can be **identified using MRI CNR**. Our findings suggest that the **differentiation** between the smooth and striated layers of the sphincter **decreases with age**.

We hypothesis that the **age-related decrease in CNR** observed on MRI correlates with the **fiber dropout** seen in histologic studies, however**, future studies** are needed to validate this hypothesis.

References

1. Perucchini D, et al. Age effects on urethral striated muscle: II. Anatomic location of muscle loss. Am J Obstet Gynecol. 2002;186(3):356–60.
2. Knight MJ, et al. Quantitative T1 and T2 MRI signal characteristics in the human brain: different patterns of MR contrasts in normal ageing. Magn Reson Mater Physics, Biol Med. 2016;29(6):833–42.

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