Quantification of Aging Effects on Urethral Morphology Using MRI

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.

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.

\[ CNR = \frac{\mu_{\text{striated muscle}} - \mu_{\text{smooth muscle}}}{\sigma_{\text{striated}} + \sigma_{\text{smooth}}} \]

Results

- 18 women were included, 9 young and 9 older (Table 1).
- Striated urethral thickness did not significantly differ between groups (Figure 1F). However, most thickness measures were larger in the younger group.

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

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Young</th>
<th>Older</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Age, years</td>
<td>23.4 ± 2.3</td>
<td>74.4 ± 4.3</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Body Mass Index, kg/m²</td>
<td>24.9 ± 2.5</td>
<td>28.1 ± 7.2</td>
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<tr>
<td>Parity</td>
<td>0</td>
<td>0</td>
<td>--</td>
</tr>
<tr>
<td>Contrast to Noise Ratio (CNR) between Smooth and Striated Muscle</td>
<td>0.84</td>
<td>0.56</td>
<td>.09</td>
</tr>
<tr>
<td>Urethral Striated Sphincter Length, mm</td>
<td>18.3 ± 4.1</td>
<td>20.7 ± 3.8</td>
<td>.24</td>
</tr>
</tbody>
</table>

• Striated urethral sphincter length was similar between groups (Table 1).
• MRI signal CNR is non-significantly higher in the younger women (p=0.9) (Table 1).
• Post-hoc power analysis showed 47% power to detect a difference between groups with α = 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