

Smooth mode Erbium:YAG Laser may improve stress urinary incontinence (SUI) by activating the estrogen signaling pathway

Background. Stress urinary incontinence (SUI) is a common decrease in old women and can seriously compromise their quality of life. Clinically, it has been shown that Smooth mode ER: YAG laser can improve SUI symptoms, but the therapeutic mechanisms remain unclear. This study aims to explore the possible mechanisms of therapeutic effect for SUI.

Methods. Forty-nine age-matched female Sprague-Dawley rats (250–300g) were separately randomized into Control (n=17), vaginal distension (VD, n=17), and VD + laser treatment (VD+LT, n=15) groups. VD+ LT group received a single Smooth mode ER:YAG laser treatment session using handpiece R09-2Gu 3 days after VD (2.0 J/cm², 7-mm spot, 1.4 Hz, 7 pulses). All groups underwent functional and histological examination 8 days after VD. Bulk RNA-seq and single-cell sequencing were conducted to explore the therapeutic mechanisms as well.

Results

1. Functional and Histological Examination

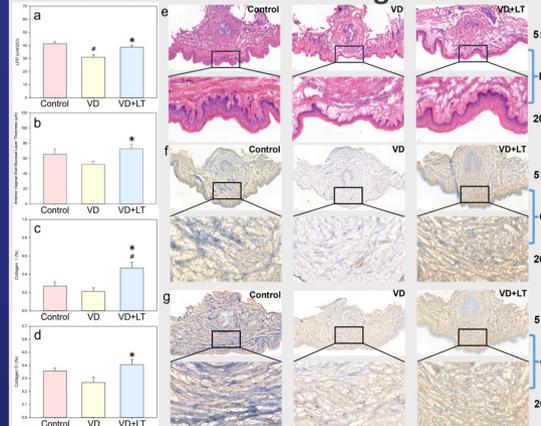


Figure 1. Smooth-mode ER:YAG laser treatment can significantly improve SUI symptoms. (a) Leak point pressure (LPP). (b) Thickness of the anterior vaginal wall mucosal layer. (c) Quantification of collagen I content. (d) Quantification of collagen III content. # indicates a statistically significant difference compared to Control; * indicates a statistically significant difference compared to VD (P < 0.05).

2. Bulk RNA-seq

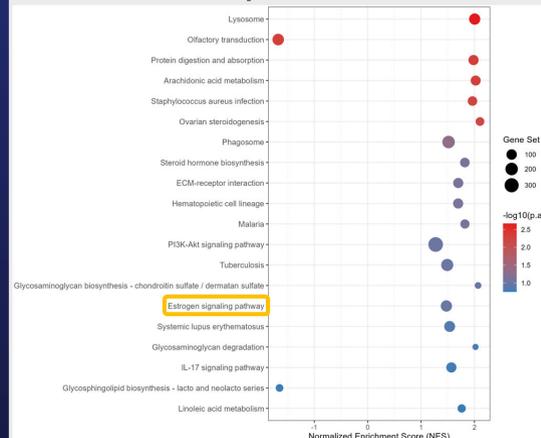


Figure 2. KEGG GSEA enrichment of bulk RNA-seq. KEGG GSEA enrichment of the urethra and anterior vaginal wall from VD and VD+LT. Compared to VD, estrogen signaling pathway is upregulated in VD+LT.

3. Single-cell Sequencing

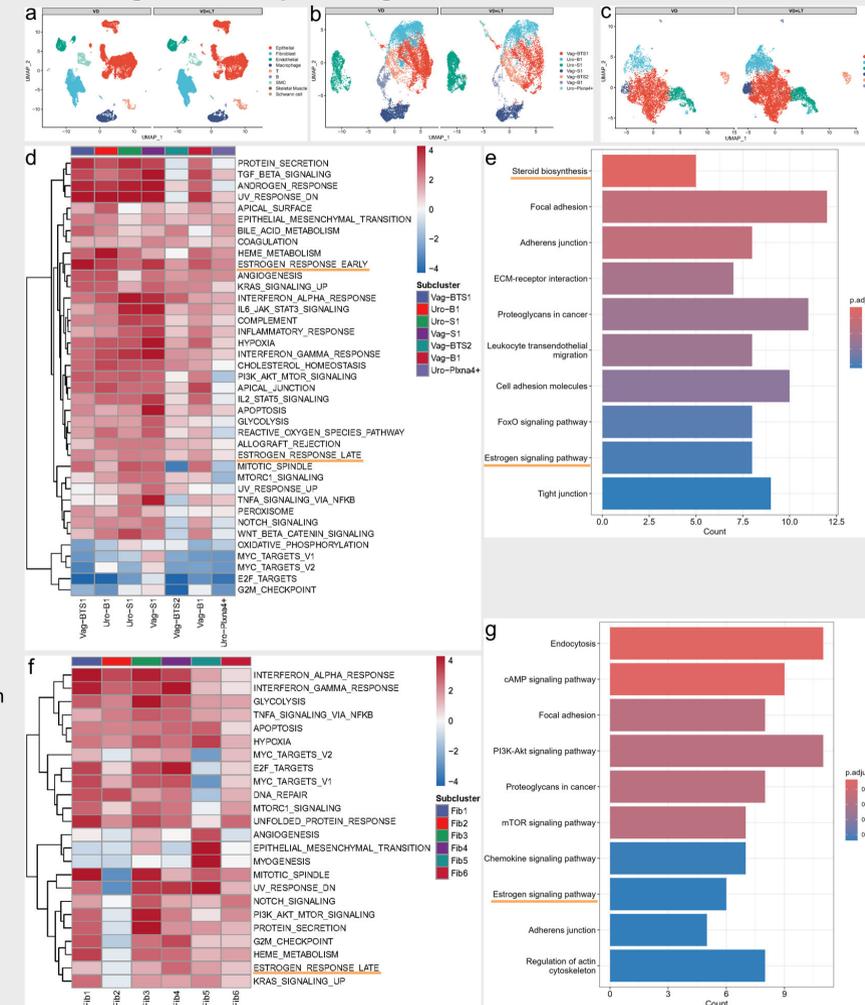


Figure 3. Single-cell RNA-seq results. (a) UMAP plots of the major cell populations in urethra and anterior vaginal wall (VD and VD+LT). (b) UMAP plots of epithelial cells. (c) UMAP plots of fibroblasts. (d) GSEA enrichment of epithelial cell subtypes. (e) KEGG enrichment of epithelial cell subtypes. (f) GSEA enrichment of fibroblast subtypes. (g) KEGG enrichment of fibroblast subtypes. Yellow underlined pathways represent possible upregulated estrogen-related signaling pathways in VD+LT compared to VD.

Conclusion. Smooth mode ER:YAG laser can effectively improve SUI symptoms, which may play a therapeutic role through estrogen signaling pathway. Further studies should be focused on confirming whether activated estrogen signaling pathway plays an important role in SUI treatment using Smooth mode ER: YAG laser.

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