

Short-Term Superiority of Transvaginal CO₂ Laser versus Radiofrequency in Stress Urinary Incontinence: A 12-Month Retrospective Cohort Analysis

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Background: Approximately 20% of females experience stress urinary incontinence (SUI) during their lifetime. Emerging energy-based therapies, such as CO₂ laser and radiofrequency (RF), lack comparative evidence regarding efficacy stratification based on disease severity and patient characteristics.

Objective: This study aims to compare the 6- and 12-month outcomes of transvaginal dot-matrix CO₂ laser therapy versus AI temperature-controlled RF therapy in SUI patients, categorized by symptom severity.

Methods: A retrospective analysis was conducted on 106 women (52 treated with laser therapy and 54 with RF therapy) who received standardized treatments. Primary outcomes included the reduction in the 1-hour urine pad test and changes in Questionnaire of International Consultation on Incontinence Questionnaire-Short Form (ICI-Q-SF) scores, while secondary outcomes comprised Patient Global Impression of Improvement (PGI-I) scores and complication rates.

Results: After 6 months, the laser group exhibited a higher overall effective rate compared to the RF group (86.5% vs. 70.4%), with particularly superior outcomes in patients with mild SUI (pad test: 92.6% vs. 58.8%, $p=0.017$; ICI-Q-SF: 5.35 ± 3.11 vs. 6.98 ± 3.86 , $p<0.05$). After 12 months, therapeutic equivalence was observed across all SUI severities, although RF demonstrated better sustained efficacy in moderate to severe cases (pad test: 70.27% vs. 40%, $p=0.018$; PGI-I: 2.87 ± 0.89 vs. 3.37 ± 1.01 , $p=0.009$).

Conclusion: CO₂ laser therapy provides rapid symptom control for mild SUI, whereas RF therapy offers greater durability in more severe cases. These findings suggest that treatment modality selection should be personalized based on the severity of the disease and duration.

Keywords: stress urinary incontinence, transvaginal, CO₂ laser, radiofrequency, laser

Stress urinary incontinence (SUI) refers to the involuntary discharge of urine caused by the sudden increase in abdominal pressure, such as coughing and sneezing, which is a common disease among women, which can particularly generate negative emotions such as anxiety, depression, loneliness, and morbid stigma, leading to social alienation and lower quality of life.¹ The incidence of SUI in Chinese women is 18.9% in 2006, and 7.04% in 2021 due to the reasons like the transition of child-related policies, the promotion of pelvic floor rehabilitation across the country.² The high-risk factors for new SUI include childbirth, body mass index, diabetes, and age.³ A cross-sectional study involved 476 participants indicated that higher knowledge scores (OR = 1.101, $p<0.001$) and higher education levels were associated with proactive practices. It is vital to implement targeted educational programs aimed at improving understanding and attitudes towards stress urinary incontinence in pregnant and postpartum women.⁴ Currently, the devices used in the female genitourinary system are divided into dot-matrix laser, radio frequency, and high-intensity focused



electromagnetic field therapy.⁵ The more common physiotherapy methods include pelvic floor muscle training, biofeedback electrical stimulation, and magnetic stimulation. Recent advancements in minimally invasive therapies have positioned vaginal CO₂ laser and radiofrequency as potential alternatives to surgical interventions.^{6–8} Evidence suggests that minimally invasive, energy-based devices-radiofrequency and laser therapy-are effective at vaginal tightening and decreasing symptoms of genitourinary syndrome of menopause (GSM).⁷ RF therapy is effective and safe for treating mild to moderate SUI, potentially due to anatomical changes included reduced bladder neck mobility, decreased vaginal width, and a reduced rotation angle of the proximal urethra.⁹ However, existing comparative studies predominantly focus on short-term vulvovaginal rejuvenation effects rather than SUI specific outcomes, and there are few reports on the comparison of mid-long-term efficacy of the two in SUI.¹⁰ Crucially, no previous research has stratified therapeutic response by baseline SUI severity-a critical knowledge gap given the distinct pathophysiological mechanisms in mild (urethral hypermobility) versus moderate-severe (intrinsic sphincter deficiency) cases.¹¹ This study collected the complete case data of patients with SUI who underwent regular laser and radiofrequency therapy in the outpatient department in recent years, aiming to provide a basis for the clinical physiotherapy treatment of SUI.

Data and Methods

General Information

This single-center retrospective cohort study adhered to STROBE guidelines. A total of 345 female SUI patients who were admitted to the pelvic floor rehabilitation Clinic of Fujian Maternal and Child Health Hospital between October 2020 and June 2022 were included, with follow-up through August 2024. After excluding the cases of incomplete general data, follow-up data and the incomplete treatment, 106 cases were included in the study, 52 cases in the laser group and 54 cases in the RF group (Figure 1. Consort flow chart). All patients and their families gave informed consent and signed informed consent. This study has been approved by the Ethics Committee of the hospital (ethics approval number 2020YJ149).

Inclusion and Grading Criteria

(1) SUI clinical diagnostic criteria of the International Urine Control Association were met, involuntary urine leakage occurred in coughing, sneezing and postural changes, and pressure induced and bladder neck lift tests were positive. The flow of urine stops when the pressure action is stopped. There were no symptoms associated with frequent and urgent urination. (2) Ultrasound examination of pelvic floor found excessive activity of urethra and residual urine <50mL. (3) Normal cognitive and language communication skills. SUI classification criteria, objective scale of 1-hour urine pad test: 1) Mild: 2 g ≤ 1-hour urine leakage < 5 g; 2) Moderate: 5 g ≤ 1 h urine leakage < 10 g; 3) Severity: 10 g ≤ 1-hour urine leakage < 50 g; 4) Extremely severe: 1-hour urine leakage ≥ 50 g.^{11–13}

Exclusion Criteria

(1) patients with malignant tumors; (2) Previous hysterectomy, pelvic floor organ prolapse surgery, urinary incontinence surgery; (3) The POP-Q stage of pelvic organ prolapse was greater than II degree; (4) Women during pregnancy and within half a year after delivery; (5) Patients with incomplete medical history. (6) Diabetic patients.

Observation Indicators

The following indexes were observed before treatment, 6 months after treatment, and 12 months after treatment: 1-hour urine pad test, International Incontinence Consultation Questionnaire (ICI-Q-SF),¹⁴ and Patient Global Impression of Improvement (PGI-I) score. Objective indicators improved by 1-hour urine pad test: Cure: cough and other abdominal pressure increased without urine leakage. Improvement: Urine leakage occurred when cough and other abdominal pressure increased, and urine leakage in 1-hour urine pad test was reduced by more than 50% compared with before. Ineffective: Urine leakage occurred when abdominal pressure was increased, such as cough. Urine leakage in 1-hour urine pad test was reduced by less than 50% compared with before. Effective rate = (cure + improvement) cases/total cases × 100%. Cure: < 2 g pad weight; improvement: > 50% pad weight reduction from baseline; failure: ≤ 50% pad

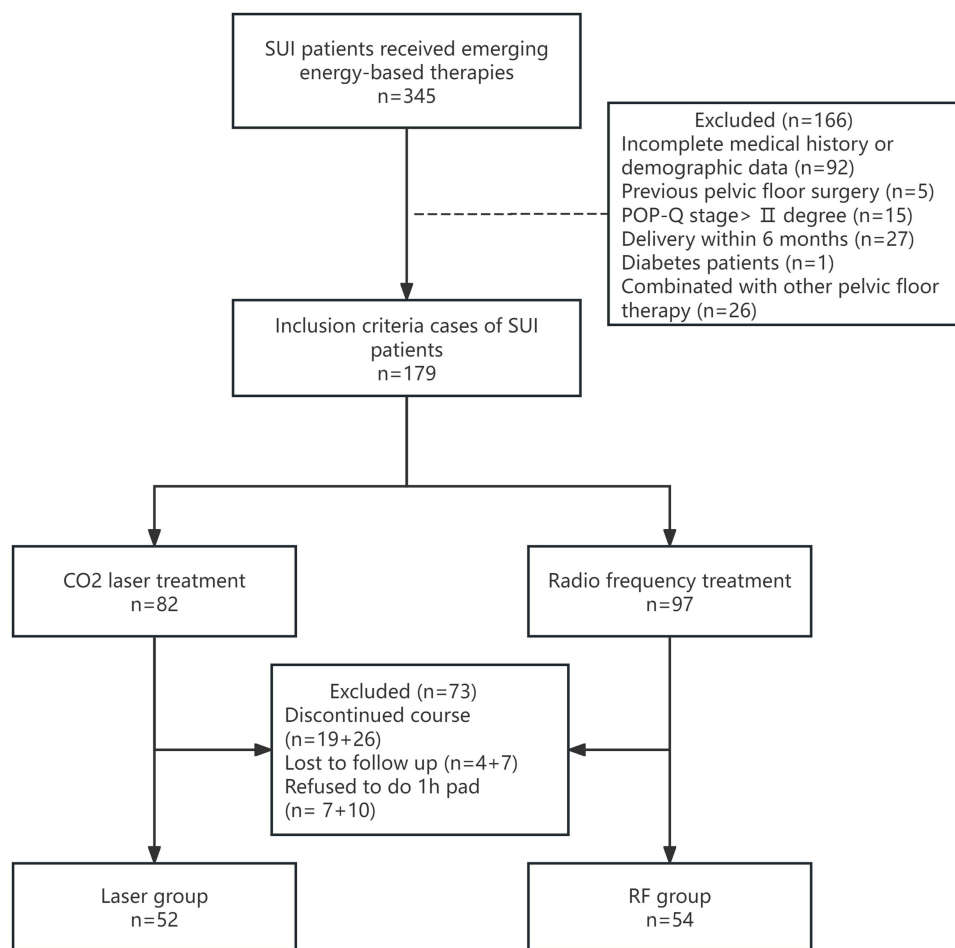


Figure 1 Cohort flowchart.

weight reduction from baseline. Subjective Indicators: PGI-I, and scores of 1, 2, 3, and 4 corresponded to “very much better”, “much better”, “better” and “no better”, compared with baseline.

Methods

All patients were treated by the same experienced pelvic floor specialist. After emptying the bladder, the patients were placed in bladder lithotomy position and the vulva and vagina were disinfected with iodophor. The selection and operation of instrument parameters for the two treatment methods are as follows:

Dot Matrix CO₂ Laser Treatment (as Shown in Figure 2A)

Using dot matrix CO₂ laser (DEKA M.E.L.A., Italy). Company SmartXide² system), 10600 nm wavelength, connected to Hiscan Dot scanner, parameter selection: The power is 40W/40W/30W, the residence time is 2000 μs, the point spacing is 1000 μm, the laser adopts a single pulse mode, selects a cylindrical 360-degree inner cathode hand, and sets an interpolator. The specific procedures are as follows: the patient takes the lithotomy position, inserts the sterile laser hand sleeve, gently pushes the hand until the resistance stops (reaching the cervix), steps on the foot pedal, fires the laser, gradually retreats the hand according to the number on the scale, and scans it as it retreats until the hand retreats to the vaginal opening to ensure that all areas in the vagina are treated. The above operations are repeated three times. Laser treatment was performed once a month for 3 months. Abstain from sex for a week after each treatment and avoid strenuous exercise.

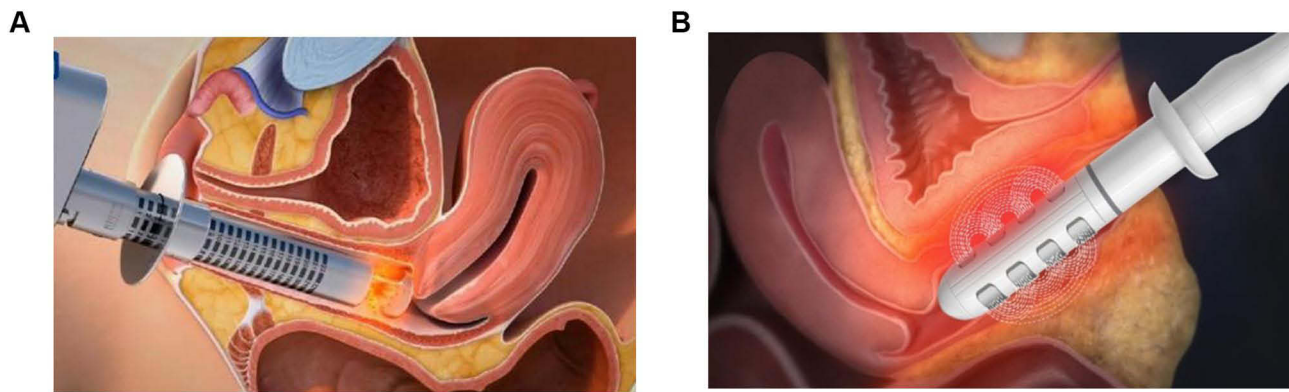


Figure 2 (A) Dot matrix CO₂ laser. (B) AI temperature-controlled radiofrequency.

AI Temperature-Controlled Radiofrequency Treatment (as Shown in Figure 2B)

Using AI temperature-controlled radiofrequency therapy instrument (Shenzhen Peninsula Medical Co., LTD.), select the inner cathode single and bipolar module, parameter Settings: temperature 42–45°C, power 35–45W, action time is 25 min. Apply sterile gel evenly to the treatment head and vaginal opening, ask the patient to relax, gently place the treatment head into the patient's vagina, the depth of the indicated line. Point A of the treatment handle is aligned with the clitoris, step on the foot once, and the treatment begins. Unipolar: rotate the handle clockwise according to A→B→C, and treat each point for 5 min, a total of 15 min; Bipolar: Rotate the handle clockwise according to A→B, and treat each point for 5 min, a total of 10 min. During treatment, the handle can be slightly rotated according to the patient's tolerance. Once every 10 to 14 days, a total of 10 times/treatment.

Statistical Analysis

SPSS Statistics version 26 (IBM) was used for data analysis. Characteristics of participants are reported with measures of central tendency or counts with percentages. Measurement data were expressed as mean ± standard deviation (SD). Intragroup comparisons between pre-treatment and post-treatment were analyzed using the paired t-test. Intergroup comparisons were conducted with the independent sample t-test, nonparametric test, or χ^2 -test (Fisher's exact test was applied where applicable). A P value < 0.05 was considered statistically significant.

Results

General Characteristics of the Two Groups

The proportion of urinary incontinence degree between laser group and RF group was statistically significant, the proportion of mild incontinence in laser group was higher, and the proportion of moderate incontinence in radio frequency group was higher (all $P < 0.05$). There were no significant differences in the number of pregnancies, mode of delivery, menopause and BMI between the two groups ($P > 0.05$) (Table 1).

Comparison of 1-hour Urine Pad Between the Two Groups at the 6 Months and 12 Months

1-hour urine pad in the laser group were significantly decreased at the 6th month of treatment ($P < 0.01$), but there was no difference between the 12th month and pre-treatment. 1-hour urine pad in the RF group were significantly decreased at the 6th month and the 12th month of treatment ($P < 0.05$). However, there was no significant difference between the two groups at the 6th month and the 12th month of treatment (Table 2).

Comparison of Severity Between the Two Groups at the 6th Month and the 12th Month

The total effective rate of laser at the 6th month was higher than that of RF group (86.5% VS 70.4%), the difference was statistically significant ($P = 0.044$), especially in the mild UI was higher than that of RF group (92.6% VS 58.8%), the

Table 1 General Characteristics of the Two Groups [$\bar{X} \pm s/n(\%)$]

	Laser Group (N=52)	RF Group (N=54)	t/ χ^2	P-value
Age (years)	41.29±7.47	39.35±6.75	1.401	0.164
Number of pregnancies	3.13±1.70	2.93±1.37	0.667	0.226
Number of births	2.04 ± 0.50	1.74 ± 0.59	2.480	0.326
BMI (kg/m ²)	22.37±2.78	22.48±2.95	0.043	0.836
Postmenopause (case, %)	4 (7.69)	3 (5.56)	0.196	0.658*
Delivery mode (case, %)			3.797	0.150*
Number of vaginal births	50 (96.2)	49 (85.2)		
Number of cesarean births	1 (1.92)	3 (5.56)		
Number of both births	1 (1.92)	2 (9.26)		
Degree of UI (case, %)			9.069	0.028*
Mild	27 (51.9)	17 (31.5)	4.559	0.033
Moderate	8 (15.4)	18 (33.3)	4.610	0.032
Severe	10 (19.23)	16 (29.6)	1.547	0.214
Extremely severe	7 (13.4)	3 (5.56)	1.938	0.197*

Note: *present Fisher's Exact Test.

Table 2 Comparison of 1-hour Urine Pad Between the Two Groups at the 6 Months and 12 Months (g)

Groups	Pre-Treatment	6th Month	P1	12th Month	P2
Laser group	18.21±28.51	9.44±20.54	0.000	16.15±30.74	0.397
RF group	14.97±22.22	6.58±10.96	0.000	9.38±12.73	0.013
P	0.515	0.371	/	0.139	/

Notes: P1 represents a comparison between the 6th month and pre-treatment in each group; P2 represents a comparison between the 12th month and pre-treatment in each group; / represents not applicable.

difference was statistically significant ($P = 0.017$), but no statistically significant difference between the two groups at the 12th month ($P = 0.510$). For all moderate, severe, and extremely severe urinary incontinence, the efficacy of laser group was lower to RF group in 40% (10/25) vs 70.27% (26/37) ($P = 0.018$) (Table 3).

Table 3 Comparison of Severity Between the Two Groups at the 6th Month and the 12th Month (Case)

	6th Month			12th Month		
	Laser Group	RF Group	P	Laser Group	RF Group	P
Mild	25/27 (92.6)	10/17 (58.8)	0.017*	17/27 (63.0)	9/17 (52.9)	0.510
Moderate	8/8 (100)	13/18 (72.2)	0.281*	4/8 (50)	13/18 (72.2)	0.382*
Severe	8/10 (80)	13/16 (81.3)	0.937*	3/10 (30)	11/16 (68.8)	0.105*
Extremely severe	4/7	2/3	/	3/7	2/3	/
Total cases	45/52 (86.5)	38/54 (70.4)	0.044	27/52 (51.9)	35/54 (64.8)	0.178

Notes: * represents Fisher's Exact Test; / represents cases <5 not analyzed.

Table 4 Comparison of PGI-I Between the Two Groups at the 6th Month and the 12th Month (Case)

Score	6th Month			12th Month		
	Laser Group	RF Group	P	Laser Group	RF Group	P
1 = very much better	1	5	0.206*	1	4	0.363*
2 = much better	26	14	0.010	8	13	0.262
3 = better	16	22	0.285	19	23	0.524
4 = no better	9	13	0.390	24	14	0.030*
PGI-I average score	2.63±0.79	2.80±0.92	0.335	3.37±1.01	2.87±0.89	0.009

Note: *presents Fisher's Exact Test.

Table 5 Comparison of ICI-Q-SF Scores Between the Two Groups at the 6th Month and the 12th Month (Score)

Groups	Pre-Treatment	6th Month	D6	12th Month	D12
Laser group	9.85 ± 3.89	5.35 ± 3.11	3.96±3.33	7.50 ±4.40	2.35±3.09
RF group	9.31 ± 3.55	6.98 ± 3.86	2.72±3.02	6.72 ± 3.55	2.59±3.07
P	0.464	0.018	0.047	0.317	0.681

Notes: D6 represents the difference of ICI-Q-SF score between at pre-treatment and the 6th month; D12 represents the difference of ICI-Q-SF score between at pre-treatment and the 12th month.

Comparison of PGI-I Between the Two Groups at the 6th Month and the 12th Month

The PGI-I score of the laser group was not different from that of the RF group at the 6th month, but the number of people who felt much better after treatment was higher than that of the RF group, and the difference was statistically significant ($P < 0.05$). The PGI-I score of the laser group at the 12th month was significantly higher than that at the 6th month (3.37 ± 1.01 VS 2.63 ± 0.79) ($P = 0.009$), and the number of people with subjective ineffectiveness was higher than that of the RF group ($24/52$ VS $14/54$) ($P = 0.030$). There was no significant difference in PGI-I scores between the RF group at the 12th month and at the 6th month (Table 4).

Comparison of ICI-Q-SF Scores Between the Two Groups at the 6th Month and the 12th Month

There was no statistical significance in ICI-Q-SF scores between the two groups at the pre-treatment and at the 12th month ($P > 0.05$). The score of the laser group was lower than that of the RF group (5.35 ± 3.11 VS 6.98 ± 3.86) at the 6th month, and the score of the laser group was lower than that of the RF group, the difference was statistically significant ($P < 0.05$). However, there was no significant difference between the two groups at the 12th month (Table 5).

Comment

SUI is a relatively common pelvic floor disease in postpartum. It affects the quality of life and physical and mental health of patients of all ages to different degrees. At present, the population tends to be aging, and the development of various new media promotes the education and science popularization of the disease, as well as the improvement of people's requirements for quality of life, so this disease has attracted increasing attention. A variety of treatment options exist for stress incontinence, ranging from nonsurgical management options of observation, pelvic floor physical therapy, vaginal inserts or magnetic and electrical stimulation.

The new energy technology can promote the regeneration and reconstruction of collagen, improve the elasticity and strength of ligaments and fascia, and repair the pelvic floor supporting tissue to achieve the purpose of treating pelvic floor diseases. The most common treatment is laser and radiofrequency therapy. Juhász MLW identified 59 studies treated for vaginal rejuvenation using either radiofrequency or fractional ablative laser therapy, and the review demonstrates radiofrequency and laser are efficacious for the treatment of vaginal laxity and/or atrophy.⁷ In our study, the efficacy of

the two in the treatment of stress urinary incontinence was objectively evaluated through medium and long term observation, combined with the 1-hour urine pad and questionnaires. It has been shown that pad tests have high diagnostic accuracy, but variation in standardisation of the parameters used (bladder volume and degree of provocation) reduces their utility in daily clinical practice. Tests of shorter duration and standardised exercise protocols have higher specificity but lower sensitivity.¹⁵ So this study combined the 1-hour urine pad with PGI-I questionnaire to evaluate the effect. What's more, the ICI-Q-SF could be an appropriate substitute for the 1-hour pad weight testing in predicting the severity of urinary incontinence.¹⁶ The result suggested that both of them could reduce 1-hour urine pad volume and ICI-Q-SF questionnaire score (see Table 2 and Table 5), indicating that both could effectively treat SUI.

At the 6th month, the weight of 1-hour urine pad was significantly lower than before treatment in the two groups (both $P < 0.01$). The composition ratio of urinary incontinence was different between the two groups. Therefore, objective effective rate was compared between the groups of patients with different degrees of urinary incontinence (see Table 3). It was found that at the 6th month, the total response rate in the laser group was higher than that in the RF group by 86.5% (45/52) VS 70.4% (38/54), especially in patients with mild incontinence (92.6% VS 58.8%). The PGI-I questionnaire was used to compare the degree of the effectiveness, indicating that more people scored 2 (much better than before) in the laser group than in the RF group after 6 months (see Table 4). And the ICI-Q-SF questionnaire score and the difference of reduction quantity (Table 4 D6) in the laser group were both lower than those in the RF group. In conclusion, the treatment effect of laser for SUI is better than that of radiofrequency at the 6th month.

At the 12th month, the weight of 1-hour urine pad was not lower than before treatment in laser group, but was still lower than pre-treatment in the RF group ($P = 0.013$). The total effective rate (51.9% VS 64.8%) and ICI-Q-SF questionnaire score were not significantly different between the two groups. The PGI-I score at the 12th month in the laser group was significantly higher than that at the 6th month (3.37 ± 1.01 VS 2.63 ± 0.79) ($P=0.009$), and higher than the RF group, as the number of PGI-I questionnaire scores of 4 (no better) in the laser group was significantly higher than that in the RF group (24/52 VS 14/54) (see Table 4). In summary, it can be concluded that the curative effect of laser is significantly lower at the 12th month than that at the 6th month, and the overall curative effect is similar to temperature-controlled radiofrequency.

The Integral Theory put forward by professor Petros theory, suggests that the most important structures in the pelvic floor that actually act as tension or pull to protect it from damage and maintain its integrity are the fascia and ligaments, and the muscles are responsible for protecting the fascia ligaments from damage under stress.^{17,18} Fascia and ligaments play a decisive and crucial role in the occurrence and development of pelvic floor dysfunction.¹⁹ Collagen is the main component of supporting these structures, and plays an important role in maintaining the elasticity and toughness of pelvic floor supporting tissues. The decrease of collagen content leads to the decrease of tension of ligaments, fascia and other anatomical structures, resulting in the relaxation of supporting structures, and ultimately the occurrence of pelvic floor diseases.^{20,21} The main symptom with pubourethral ligament laxity is urine loss with stress. The main symptom with external urethral ligament laxity is urine loss on sudden movement with the accompanying sensation of a "bubble" escaping.¹⁷

A randomised controlled trial compared the effects of microablative and non-ablative laser and radiofrequency treatment on women with genitourinary syndrome of menopause. The result revealed that all treatment energies resulted in significant increases in tissue thickness ($p < 0.001$), layer number ($p < 0.001$), and collagen quantity and depth ($p < 0.001$), with no significant difference among the groups.²² Carbon dioxide laser and Erbium-YAG laser are used in the treatment of SUI.²³ By transferring energy to deep submucosal vaginal tissues, it causes tissue fibers to contract without being destroyed, promotes capillary reconstruction, improves microcirculation, increases tissue oxygen content, promotes collagen tissue regeneration and reconstruction, thickens the vaginal covering squamous epithelium, improves vaginal biomechanics, and repairs pelvic floor supporting tissues.^{24,25} Loss of collagen is common in SUI patients, and collagen is an important component of pelvic floor support. Transvaginal CO₂ laser therapy can promote collagen synthesis and increase the elasticity of collagen and provide good support for pelvic floor structure by rebuilding collagen to achieve treatment purposes. Bretas TLB's study found that after three sessions of carbon dioxide CO₂ laser application, histological findings revealed epithelial atrophy reversal and collagen remodeling of the vaginal wall.

Immunohistochemical analysis showed an increase in collagen type III fibers.²⁶ Therefore, dot matrix CO₂ laser can reduce the number and volume of urine leakage, ICI-Q-SF questionnaire score and PGI-I score to treat SUI.

In this study, the medium and long-term curative effect of treatment was observed, and the curative effect was still obvious after 6 months, but significantly decreased after 12 months, with the effective rate decreasing from 86.5% to 51.9%, which was related to the local action principle of vaginal tissue contraction in a short period of time with laser. After 12 months, collagen loss and the weakening of local effect resulted in SUI recurrence. The total time of laser endovaginal treatment is within 5 minutes, which is a thermal stripping effect directly acting on the vaginal mucosal tissue, with more powerful energy and rapid remodeling of collagen through self-coagulation effect, so the short-term effect is more obvious, and the effect is not long-lasting because its effect is only limited to the vagina and mucosal lamina propria. A prospective, open-label, cohort study by Dabaja H of 33 women with SUI completed three outpatient treatments with laser therapy and were subsequently evaluated safety and efficacy at 1, 3 and 6 months. Sanitary pad usage decreased from a median of 12 per day at baseline to 7 at 1–3 months post-treatment ($P < 0.0001$) and returned to 12 at 6 months post-treatment. Scores on the Urogenital Distress Inventory and the International Consultation of Incontinence Questionnaire decreased (improved) significantly at 1–3 months post-treatment returned to levels similar to baseline at 6 months after treatment.²⁷ The result also suggested that the short-term curative effect was significant after treatment, and the curative effect decreased after 6 months, but the reason was not analyzed in the article. A double-blind randomized sham-controlled trial from Lee P et al suggested that 2 vaginal Er: YAG laser therapies 6 weeks apart was no more effective than sham (participants 76 VS 68) for curing or improving female stress urinary incontinence at 6 months.²⁸ Another single-blinded, multicenter randomized controlled trial involved 75 participants showed significant reductions in Pelvic Floor Distress Inventory (PFDI) Urinary Distress Inventory (UDI) stress subscale scores in the treatment group at the 6-month and 12-month follow-up ($p < 0.001$) but was not significant in the control group, and also significant reductions were observed in the treatment group at the 6-month and 12-month follow-up in all secondary outcome parameters, just as the same result as our study.²⁹ The results of our study showed that the effective rate was still high after 6 months, and the number of patients who felt much better after treatment (PGI-I score = 2) in the laser group was higher than that in the RF group ($P < 0.05$). After 12 months, the effective rate decreased significantly, which was no different from that of radiofrequency.

Radiofrequency is a kind of high-frequency alternating current changing electricity, which can cause directional or vortex movement of electrons and ions in the target tissue and high-frequency vibration of polar molecules to produce thermal effects to achieve therapeutic purposes. It can activate fibroblasts to secrete collagen, stimulate collagen and elastin remodeling, restore the elasticity and water of vaginal surface,⁸ promote the regeneration of small nerves and small blood vessels in the treatment area, promote blood circulation, improve cell function and tissue metabolism, and enhance the elasticity and strength of fascial ligament. Relief of fascial ligament spasm increases the ability of pelvic floor muscles to work together. Allan BB's data indicate an improvement in SUI symptoms and quality of life for subjects, as determined by validated SUI-related patient-reported outcomes and the objective one-hour pad weight test, with a >50% reduction in pad weight from baseline for 52% of the subjects at 12 months,³⁰ which were similar to those in our study, where the response rate was 72.2% after 6 months and 68.5% after 12 months. Furthermore, our previous study also demonstrated that radiofrequency treatment for SUI was effective, regardless of the unipolar and comprehensive mode treatment, and no difference in efficacy between the two groups. The efficiency at 1, 3, 6 and 12 months after comprehensive mode treatment were as follows: 66.7%, 68.5%, 71.7% and 62.5%, respectively.³¹

In this study, the effect of laser on mild SUI was better than that of radiofrequency, but the effect of radiofrequency on SUI lasted longer than that of laser. Both of them increase collagen, but the efficacy and duration are different, and the reason is related to the pathogenesis and treatment mechanism of stress urinary incontinence. Both laser and radiofrequency treat urinary incontinence by promoting collagen regeneration and reconstruction to repair the supporting structures of the pelvic floor. As the retrospective review of lasers and radiofrequency devices on vaginal rejuvenation, nonablative radiofrequency and microablative fractional lasers for vaginal rejuvenation use the same basic mechanism thermal injury to discrete areas of tissue, without full ablation, leaving surrounding tissue intact, promoting the wound healing cascade, fibroblast activation, collagen remodeling, neocollagenesis, neoelastosis, and neoangiogenesis.⁷ Passage of a low energy radiofrequency electrode through the vagina creates resistance, heating tissue to approximately 40 to

45°C and causing collagen contraction; these temperatures avoid macroscopic damage because there is no proteindenaturation or cell necrosis. CO₂ carbon dioxide laser therapy target water as their chromophore. Microscopic columns of epidermis and dermis are ablated with 5 to 12 J/cm² at 120 to 200°C creating microthermal treatment zones. The surrounding tissue is left intact and provides necessary growth factors for tissue regeneration.³² CO₂ laser is often used to autocoagulate and decrease bleeding risk. The laser only acts on the local mucosal tissue, which is the thermal stripping effect of the instantaneous vaginal mucosal tissue. The energy is more powerful, the vaginal mucosa is contracted strongly, and the folding Angle formed by the urethra and the bladder is pulled, so the effect of improving mild urinary incontinence is more obvious. The results of Tien YW al.³³ also suggest the effect of the IncontiLase procedure for mild SUI was moderate at the 6-month follow-up, but the procedure was not effective for pad weight >10 g. The results showed that the effect of laser on severe urinary incontinence was not as good as that on mild urinary incontinence. Serati M's study also suggested that the effectiveness of laser therapy for severe SUI is very low for older women and those who are overweight or obese.³⁴ The laser only acted on the lamina propria of the vaginal mucosa and could not act on the pelvic fascial ligament. Radiofrequency slowly penetrates the entire pelvic fascia and ligament through the warm effect of nearly half an hour. Although the energy is smaller, the depth of its action can reach the superficial muscle layer, which is conducive to the overall repair of the ligament, fascia and muscle, so the effect may be slow but more lasting. In summary, the pelvic floor damage of mild SUI was mild, and the local repair efficiency by laser was better than that by radiofrequency, but the curative effect was not lasting. Patients with moderate or severe urinary incontinence often have urethral sphincter injury or pelvic floor defects, so the therapeutic effect of laser is not good.

Limitations

This study is subject to several inherent limitations owing to its retrospective design. First, as a retrospective cohort study, we were unable to collect complete multi-dimensional evaluation indices at the 6- and 12-month follow-up time points for stress urinary incontinence. Key assessments including pelvic floor electromyography, 24-hour urine pad testing, and other relevant validated questionnaires were not fully available for all participants, which may have restricted the thoroughness of our comparative efficacy analysis of the two therapeutic modalities. Second, the non-homogeneous baseline distribution of stress urinary incontinence severity between the two groups, which may compromise the objectivity of direct intergroup comparisons of long-term efficacy. We have mitigated this limitation by conducting stratified efficacy analyses according to the different grades of urinary incontinence severity.

Conclusions

This real-world evidence establishes vaginal CO₂ laser as the preferred modality for rapid symptom control in mild SUI, while radiofrequency demonstrates superior durability for complex cases. The effectiveness of laser after 6 months is higher than that of radiofrequency, but there is no difference after 12 months. The proposed severity-based treatment algorithm still requires validation through multicenter randomized, controlled trials, particularly regarding cost-effectiveness and long-term (>24 months) outcomes.

Patient and Public Involvement

It was not appropriate or possible to involve patients or the public in the design, or conduct, or reporting, or dissemination plans of our research.

Data Sharing Statement

The data associated with this study are provided in the [Supplementary Material](#).

Ethics Approval and Consent to Participate

The present study was conducted in accordance with the Declaration of Helsinki. This study has been approved by the Ethics Committee of Fujian Maternity and Child Health Hospital (ethics approval number 2020YJ149). All participants signed a treatment consent form prior to receiving transvaginal CO₂ laser or AI temperature-controlled radiofrequency therapy, acknowledging full understanding of the treatment procedures, potential benefits, and risks.

Acknowledgments

The authors would like to express their gratitude to the participants who participated in the study.

Author Contributions

Zheng Xiaohua and Lin Chaoqin equally contributed as co-first authors. Concept and design: Zheng Xiaohua, Xu Ying. Acquisition of data: Zheng Xiaohua, Lin Chaoqin, Zheng Yunyan. Analysis and interpretation of data: All authors. Drafting of the manuscript: Zheng Xiaohua, Xu Ying. Statistical analysis: Zheng Yunyan, Wang Yu. Obtained funding: Wang Yu, Lin Chaoqin, Xu Ying. Administrative, technical, and material support: Lin Chaoqin, Xu Ying. All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

The study was supported by the Natural Science Foundation of Fujian Province (2024J011055, 2024J011047), Special Fund of Chinese Association of Plastics and Aesthetics (FRPR2020-wksp-01), Fujian Provincial Health Technology Project (2024TG013).

Disclosure

The authors declare that they have no competing interests for this work.

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