

Efficacy and Safety of Vaginal CO₂ Laser Treatment in Female Stress Urinary Incontinence

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Abstract

Background: Urinary incontinence (UI) is a common disorder that affects women of various ages and impacts all aspects of life. **Objective:** Our objective was to assess the efficacy and safety of vaginal Fractional CO₂ laser treatment for mild-to-severe stages of female stress UI (SUI). **Materials and Methods:** A total of 60 women with a mean age of 47.6 ± 8 years suffering from SUI were included in this prospective, single-center, nonrandomized, pilot study. Patients were clinically examined and assessed before treatment and at each follow-up visit at 1, 3, and 6 months postvaginal fractional CO₂ laser treatment by International Consultation on Incontinence Questionnaire-UI Short Form (ICIQ-UI SF) questionnaire for assessing the degree of incontinence and its impact on the quality of life, Pelvic Organ Prolapse/UI Sexual Questionnaire (PISQ-12) for assessing the quality of life in the area of sexuality, digital assessment of muscle strength, and Q-tip test for evaluating the mobility of the urethra and bladder neck. Two or three sessions of vaginal fractional CO₂ laser treatment were performed for each woman using SmartXide² with V²LR laser. Pain during the treatment was measured at every session with a visual analog scale (VAS), any other possible adverse effect observed. **Results:** Significant improvement ($P < 0.001$) was found in ICIQ-UI scores, PISQ-12 scores, muscle strength, and Q-tip angle, at all follow-ups after treatment compared to baseline values. ICIQ-UI scores decreased at 1, 3, and 6 months follow-ups by 6.5, 7.17, and 7.30 points, respectively ($P < 0.001$). PISQ-12 scores increased at 1, 3, and 6 months follow-ups by 6.2, 7.8, and 9.1 points, respectively ($P < 0.001$). Muscle strength increased at 1, 3, and 6 months follow-ups by 1, 1.5, and 2 points, respectively ($P < 0.001$). Q-tip angle decreased at 1, 3, and 6 months follow-ups by 11.7°, 18.5°, and 24.2°, respectively ($P < 0.001$). No adverse events were reported by any patients during the procedure. **Conclusion:** This study demonstrated that vaginal Fractional CO₂ laser treatment using SmartXide² with V²LR configuration laser system is an effective and safe treatment option for patients with mild-severe SUI.

Keywords: Female stress urinary incontinence, laser treatment, vaginal CO₂ laser

INTRODUCTION

Urinary incontinence (UI) is defined by the International Continence Society as “the complaint of involuntary leakage of urine.”^[1] There are four main types of incontinence: stress, urge, overflow, and functional incontinence.^[2] Stress UI (SUI) is the most prevalent type in women and is defined as involuntary loss of urine due to sphincter failure during physical activity, coughing, or sneezing, which all cause an increase in abdominal pressure.^[3] It has an observed prevalence of between 4% and 35%.^[4]

The peak incidence of SUI occurs between 45 and 49 years of age.^[5] Risk factors cited for the development of SUI included: advanced age; obesity; vaginal deliveries, in which, damage may occur to local musculature and innervation as the fetus passes; traumatic deliveries involving forceps and/or

episiotomies; multiparity and pregnancy at an advanced age; estrogen deficiency, conditions associated with increased intraabdominal pressure; smoking; diabetes; collagen diseases; neuropathies; and history of hysterectomy.^[6]

The etiology of SUI is multifactorial. SUI may be caused by inadequate support of the pelvic organs and anterior vaginal wall suspension and/or a possible change in the intrinsic urethral closure mechanism itself,^[7,8] in addition to that, histological studies observed a reduction of collagen in the urethral wall in case of loss of urethral support and/or sphincter

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dysfunction.^[9] UI reduces the quality of life, including sexual health.^[10] Many women with incontinence report loss of urine during vaginal intercourse, which can cause embarrassment and relationship problems.^[11]

Treatment options for SUI range from conservative to surgical. Conservative options include pelvic floor muscle training (PFMT), behavioral modification, continence-support pessaries, and urethral inserts.^[12] PFMT alone can improve symptoms of stress incontinence by 56%–75% but appears to be less effective in the long term and is dependent on compliance.^[13] Surgical treatment options include anti-incontinence procedures, such as retropubic urethropexies, autologous fascial slings, urethral bulking agents, and synthetic midurethral slings.^[14] While mid-urethral sling procedures are highly effective, they are associated with adverse events and complications such as bleeding, bladder perforation, urethral injury, infection, and groin pain.^[15]

It is well known that using laser energy to achieve heat pulsing (i.e., temporarily increasing the temperature) of collagen can improve collagen structure and initiate neocollagenesis. As a result of the temperature increase, intermolecular cross-links that stabilize collagen triple-helix structure are broken, which leads to the shrinkage of collagen fibrils and improvement in tissue firmness.^[16]

Collagen is an important component of the pelvic floor supportive structures, and it makes up more than 80% of protein content of the endopelvic fascia. Childbirth trauma can lead to destruction of collagen fibers in the pelvic floor, while aging slows down the synthesis of new collagen, both resulting in decreasing collagen content.^[17] It was shown that pubocervical fasciae of incontinent women have a low collagen content^[18] and also that SUI is more frequent in women with reduced collagen content in their anterior vaginal walls.^[19]

Laser treatment to achieve heat pulsing of the endopelvic fascia and pelvic floor tissue could represent an effective nonsurgical method for treating female UI and other disorders resulting from diminished pelvic floor support.

The aim of this study was to assess the efficacy and safety of vaginal fractional CO₂ laser treatment using SmartXide² with V²LR configuration laser system for mild-to-severe stages of female SUI.

MATERIALS AND METHODS

Study population

In this prospective, single-center, nonrandomized, pilot study, conducted in the period from September 2017 to March 2018, we included 60 women with a mean age of 47.6 ± 8 years suffering from SUI, with or without mild prolapse, who met the inclusion criteria.

The inclusion criteria for recruitment to the study were history of vaginal delivery, SUI, normal cell cytology, negative urine culture, no injuries and bleeding in the vaginal canal, introitus,

and vestibule. The exclusion criteria were severe prolapse and damage of the rectovaginal fascia, patients with mixed or urge incontinence, age ≤ 18 and >70 years, pregnancy, body mass index (BMI) >30 , intake of photosensitive drugs, injury or/and active infection in the treatment area, and undiagnosed vaginal bleeding, postvoid residual urine volume >150 ml.

The study was carried out in the Obstetrics/Gynecology Clinic in Duhok, Iraq. From each patient, medical history was obtained and clinical examination performed; pelvic floor muscular strength was assessed by asking the patient to contract her pelvic muscles around the examiner's fingers; and then the Modified Oxford Grading Scale by Laycock^[20] was used to grade muscle strength, it consists of a 6-point scale: 0 = no contraction, 1 = flicker, 2 = weak, 3 = moderate, 4 = good, and 5 = strong. Laboratory studies and ultrasonic studies of the genitals and urinary bladder were performed to exclude patients with abnormal findings in the urinary and gynecology tract. Ultrasonography also enabled an assessment of residual volume in the urinary bladder.

The type of incontinence was determined on the basis of clinical examination, (it was assessed by inducing an increase in intraabdominal pressure by coughing maneuver and observing the urethra for leakage in a full and empty bladder "cough stress test." Leakage supports the diagnosis of stress incontinence), ultrasonography, and the questionnaire.

The degree of incontinence and its impact on the quality of life was assessed with the International Consultation on Incontinence Questionnaire UI Short Form (ICIQ-UI SF).^[21] The questionnaire allows the assessment of the prevalence, frequency, and perceived cause of UI, and its impact on everyday life.^[22] The results of the ICIQ-UI SF may be divided into the following four severity categories: mild (1–5), moderate (6–12), severe (13–18) and very severe (19–21).^[23]

Quality of life in the area of sexuality was examined with the validated pelvic organ prolapse (POP)/UI Sexual Questionnaire (PISQ-12) with a maximum score of 48 points. Many recent publications examining the impact of UI, fecal incontinence, and POP using validated generalized and disease-specific questionnaires have reported poorer sexual function in women with pelvic floor dysfunction (PFD). The PISQ has been used most commonly to evaluate sexual function after surgery for PFD, with increased PISQ scores in approximately 70%.^[24]

Q-tip measurement was used for the quantification of urethrovesical junction mobility and the urethral axis. The Q-tip test evaluates the mobility of the urethra and bladder neck. This is done by inserting a sterile, lubricated cotton-bud into the urethra to the level of the bladder neck. The patient is then asked to strain. The resting and straining angles are measured, and the difference between the two angles is calculated. Urethral hypermobility is commonly present in women with SUI; it is defined as being present when the Q-tip angle was $\geq 30^\circ$, while Q-tip movement $<30^\circ$ was declared as normal.^[25]

Patients were informed about the fractional CO₂ laser procedure. Afterward, patients received two or three sessions of laser treatment (a minimum interval of 30 days was required between 2 sessions); all interventions were performed in an outpatient setting. During the intervention, patients were lying in a normal gynecological lithotomy position and received no anesthesia. Pain during the treatment was measured at every session with a visual analog scale (VAS) according to the National Initiative of Pain Control.^[26] Follow-ups were performed at 1, 3, and 6 months. At each follow-up, patients were assessed as before the treatment by physical examination, Q-tip measurements as well as by self-reported questionnaires: ICIQ-UI and PISQ-12. The treatment outcome and the degree of improvement were numerically determined.

Treatment procedure

After cleaning the treated area, patients were subjected to the Monalisa Touch which is a controlled laser energy delivered to the vaginal tissue using vaginal probe connected to the handpiece of SmartXide² V²LR (vulvovaginal laser reshaping) fractional CO₂ laser system (by DEKA Italy). The probe inserted inside the vaginal canal about 4–6 cm from the introitus, with the laser's energy window oriented at 12 o'clock position. It was then rotated by 1 h at a time after each laser pulse, between positions 10 o'clock and 2 o'clock. After completing the 10–2 o'clock rotation, the handpiece was pulled back by 1 cm and the rotation was repeated. Three such passes were repeated. The following laser protocol was used: 40W for power, 1000 μs emission time, 1000 μm spacing, and a level of smart stalk of 4 (the laser beam emitted four times on the same spot with the same energy properties) DEKA pulse emission mode.

Statistical analysis

The collected data were expressed either as means ± standard deviations or numbers and percentages when appropriate. Statistical significance of the difference between mean outcomes values at baseline and at follow-up measurements was calculated using Statistical Package for the Social Sciences (SPSS Statistics 24, IBM, Armonk, NY, USA) software; with one-way ANOVA and Bonferroni test. $P \leq 0.05$ was considered to indicate statistical significance.

RESULTS

All 60 patients underwent the vaginal fractional CO₂ Laser treatment by SmartXide² with V²LR configuration. Their baseline characteristics are presented in Table 1. All procedures

were successfully completed in an outpatient clinic. The average treatment time was 10 min. The distribution of patients regarding grade of incontinence before the beginning of therapy is presented in Table 2. All patients 60 (100%) have completed the first follow-up, 1 month after the intervention. At second follow-up, 3 months after the intervention, 52 (86.66%) patients remained in the study and 8 (13.33%) were lost to follow-up. At the third follow-up, 6 months after intervention, 45 (75%) patients remained in the study, while 15 (25%) were lost to follow-up. Baseline characteristic of those who have remained in the study at later follow-ups were similar to those at the baseline Table 1.

The ICIQ-UI score was significantly decreased in all follow-ups compared to baseline ($P < 0.001$). In Figure 1, the results of ICIQ-UI score before the treatment, at 1, 3, and 6, months are represented. The mean ICIQ-UI score before the treatment was 13.36 points, the second measurement at 1 month was 6.86, at 3 months 6.19, and at 6 months 6.06.

Significant differences ($P < 0.001$) were found at the first, second, and third follow-up in all groups regarding the grade of SUI. At 1, 3, and 6 months after the intervention, the percentage of patients with ICIQ-UI score = 0 indicating no UI were 25%, 40.38%, and 48.88%, respectively, moreover, from the first follow-up 1 month after the intervention, no woman experienced very severe UI. The improvement of the grade of UI at first, second, and last follow-up is presented in Figure 2.

The PISQ-12 score was significantly increased in all follow-ups compared to baseline ($P < 0.001$). In Figure 3, the results of PISQ-12 score before the treatment, at 1, 3, and 6 months are represented. The mean PISQ-12 score before the treatment was 31.5 points, the second measurement at 1 month was 37.7, at 3 months 39.3, and at 6 months 40.6.

The mean values of the PFM strength were significantly increased in all follow-ups compared to baseline ($P < 0.001$). In Figure 4, the results of the mean values before the treatment, at 1, 3, and 6 months are represented. The mean value before the treatment was 2, the second measurement at 1 month was 3, at 3 months 3.5, and at 6 months 4.

The mean angle of the Q-tip with the Valsalva maneuver was significantly decreased in all follow-ups compared to baseline ($P < 0.001$). In Figure 5, the results of the mean angle of the Q-tip before the treatment, at 1, 3, and 6 months are represented. The mean angle before the treatment was 61.5°, the second measurement at 1 month was 49.8°, at 3 months 43°, and at 6 months 37.3°.

Table 1: Patients' characteristics at the baseline and baseline characteristics of those who remained in the study

Patient characteristics	Baseline (n=60)	1 st follow-up (n=60)	2 nd follow-up (n=52)	3 rd follow-up (n=45)
Age	47.6±8	47.6±8	47.5±7.8	47.3±7.7
Parity	3±1.14	3±1.14	3±1.10	3±1.12
Average birth weight (kg)	3.5±0.4	3.5±0.4	3.5±0.5	3.5±0.3
BMI	24.6±3	24.6±3	24.3±3.2	24.4±3.1

Data are presented as means±SD. BMI: Body mass index, SD: Standard deviation

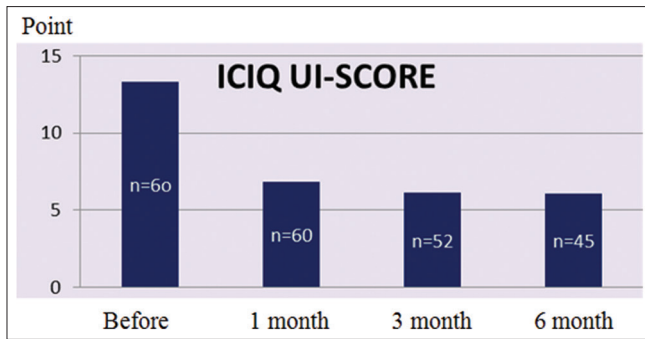


Figure 1: The mean of Incontinence Questionnaire-Urinary Incontinence Short Form score before the treatment and at 1, 3, and 6 months follow-up. The score significantly decreased (improved) after laser treatment ($P < 0.001$)

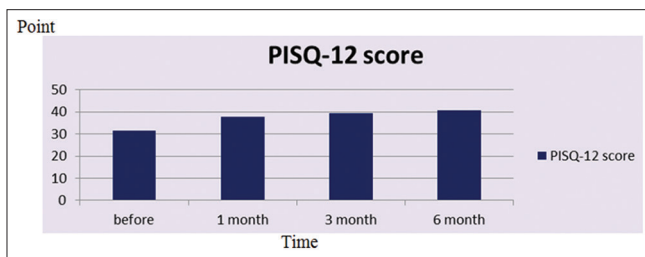


Figure 3: The mean of Pelvic Organ Prolapse/UI Sexual Questionnaire-12 score before the treatment and at 1, 3, and 6 months follow-up. The score significantly increased (improved) after laser treatment ($P < 0.001$)

Table 2: The distribution of patients regarding the grade of incontinence before the beginning of therapy

Grade of SUI	n (%)
Mild	7 (11.66)
Moderate	21 (35)
Severe	26 (43.33)
Very severe	6 (10)

SUI: Stress urinary incontinence

The VAS (0–10) pain level of 2 was reported by 5% of participants, while 95% had score 0. All patients returned to their routine activities immediately after treatment, and no adverse effects were reported.

DISCUSSION

The common mechanism of UI is PFD due to loss of its supportive function.^[3,27] The mechanical stability of the urethra and bladder neck is largely provided by intact pelvic muscles and connective tissue of the pelvis. Thus, the majority of therapeutical approaches aim at strengthening the support of the pelvic floor, either conservatively or surgically. Although there are reports on the beneficial effects of conservative treatment,^[28] patients have to be very compliant and the final outcome remains questionable. On the other hand, none of the existing surgical approaches is optimal as they are often associated with complications.^[3,29,30] Moreover, the

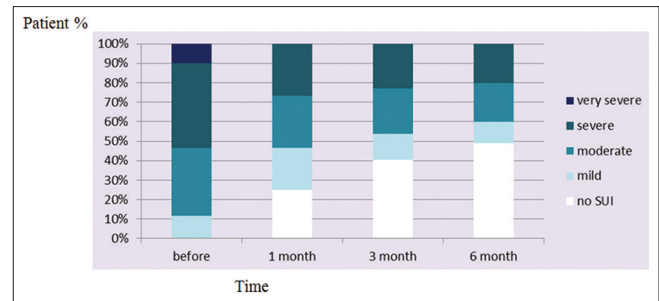


Figure 2: The effect of laser treatment on the improvement of the grade of stress urinary incontinence. Plots show the distribution of patients (in %) with regard to the grade of incontinence (mild, moderate, severe, and very severe) before the treatment and at 1, 3, and 6 months follow-up ($P < 0.001$)

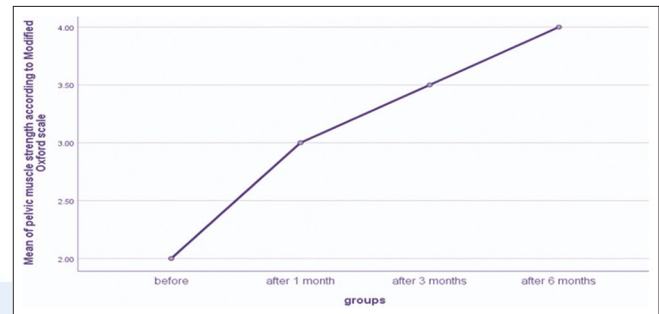


Figure 4: The mean of pelvic floor muscle strength according to the Modified Oxford Scale before the treatment and at 1, 3, and 6 months follow-up are represented. The pelvic floor muscle strength after 6 months treatment increased by 2 scale ($P < 0.001$)

American Food and Drug Administration has amended several warnings and proposed an upgrading in risk qualifications for implantable devices.^[30]

Despite its prevalence and the associated diminished quality of life, many women who experience symptoms of SUI choose to delay or do not seek medical treatment because of embarrassment, lack of knowledge about possible treatments, or fear that the treatment will require surgery. A survey found that only 15% of women aged 40 years or older with SUI sought medical treatment for their symptoms.^[31]

Minimally invasive laser intervention could be regarded as an alternative to classical, conservative, and surgical techniques. The loss of anatomical support of the periurethral structures due to age and damage of these areas is very likely due to alterations in collagen quantity or quality.^[32,33] The use of lasers can improve these alterations in connective tissue.^[34] Precisely controlled laser energy pulses delivered to the vaginal canal and introitus area cause a heating of the tissue and the collagen in it, also the process of neocollagenesis is stimulated. The irradiated tissue consequently contracts and shrinks, improving support to the bladder and thus reducing the symptoms of SUI.^[35-37]

Effective results for transurethral collagen denaturation treatments have been previously reported. Transurethral collagen denaturation resulted in significant improvements

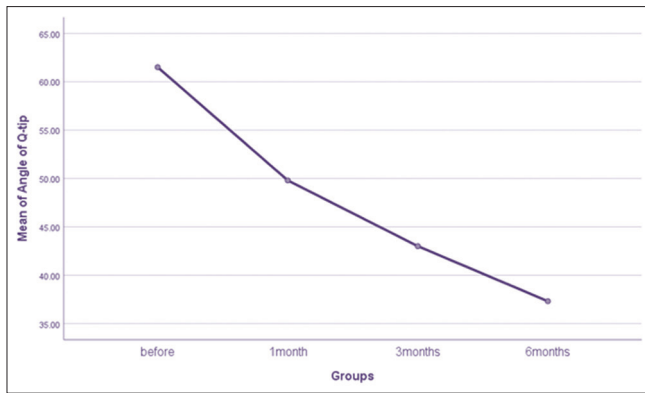


Figure 5: Angles of the Q-tip before the treatment and at 1, 3, and 6 months follow-up are represented. The Q-tip angle after 6 months treatment decreased by more than 24° ($P < 0.001$)

in stress leaks and quality of life for at least 18 months in the treatment of nonsurgical radiofrequency collagen denaturation. These treatments, however, were connected to some adverse event effects such as dysuria, urinary retention, and postprocedure pain.^[38] In a paper describing another minimally invasive laser therapy for vaginal rejuvenation treatments performed with a fractional ablative CO₂ laser, Gaspar *et al.*^[34] reported beneficial effects in the three layers of the vaginal tissue and in sexual function. They also reported several adverse events effects such as bleeding, pain, and burning.

After using the Fotona Smooth™ XS 2940 nm erbium laser device for the treatment of patients with vaginal relaxation syndrome with loss of sexual gratification, Garcia *et al.*^[39] reported improvements not only in sexual relations but also secondarily with respect to the UI with which these patients presented, very possibly due to the existence of a close relationship between the two conditions.

Different authors have demonstrated the effectiveness of treatment with erbium laser for UI.^[40] In another report studying 39 patients affected with slight-to-moderate stress incontinence who were treated using the same system, Fistonic *et al.*^[41] also demonstrated that the procedure was safe. The same author treated 73 women affected with incontinence in another prospective study in only one center and found improvements in 67% of women with a normal BMI, and in 100% of women when the treated patients were younger than 39 years of age.^[42] Ogrinc *et al.*^[43] used an erbium laser to treat 175 consecutive patients affected with incontinence, including 114 women with stress incontinence, and demonstrated that this method was effective with at least 1 year of positive effects. This report also demonstrated that this method was not suitable for mixed incontinence cases.

In our pilot study with 6-month follow-up of patients with mild-to-severe SUI treated with SmartXide² with V²LR configuration Fractional CO₂ Laser, we demonstrated the efficacy and safety of the procedure. The stress incontinence was measured by ICIQ-UI SF and showed score improvement after treatment by >7 points, at 6-month follow-ups, indicating

significant improvement of SUI symptoms. ICIQ-UI SF was shown in several studies^[22,44] to be an effective measurement method for assessment of the impact of symptom severity on the quality of life.

Regarding PISQ-12 questionnaire that measures the quality of life in the area of sexuality, many studies document an improvement in PISQ-12 score after successful treatment of SUI. A study by Handa *et al.*^[45] established that after therapy, successful nonsurgical treatment of SUI (continence pessary, behavioral therapy through PFMT and continence strategies, or combination therapy) was associated with significant improvement in PISQ-12 score. Brubaker *et al.* described PISQ-12 score increases by a mean of 5.8 points after successful surgery (Burch colposuspension or Sling surgery) and only 3.8 points for unsuccessful surgery.^[46] In our study, we have noticed a mean improvement of PISQ-12 score after 6 months by >9 points.

Digital assessment of PFM strength showed an improvement in muscle strength. The usefulness of digital assessment of pelvic floor muscle strength was shown in the study by Isherwood and Rane^[22] as there is a strong correlation between contraction strength and the ability to control urine flow, and defective pelvic floor function, which is an important component of SUI and uterine prolapse.

Quantification of urethrovesical junction mobility and the urethral axis by Q-tip test showed a decrease of the angle by more than 24° at 6-month postSmartXide² with V²LR configuration fractional CO₂ Laser treatment. Although by the results of some studies, the Q-tip “cotton swab test” test has poor predictive value for either SUI diagnosis or predicting treatment success,^[47] it has been successfully used by many clinicians to determine the urethral axis and urethrovesical junction mobility.^[48]

Apart from mild discomfort which was reported by 5% of participants, we have not noticed any adverse events throughout the whole course of treatment and the follow-up period. All patients returned to their daily activities immediately after treatment. In spite of the limitations of this pilot, single-center study, with the absence of a control group, and relatively short term follow-up, we believe that our aim to evaluate efficacy and safety of vaginal fractional CO₂ laser treatment for mild-to-severe stages of female SUI was achieved.

CONCLUSION

We conclude that the vaginal, fractional CO₂ laser treatment by SmartXide² with V²LR configuration, offers efficacious treatment for SUI in women and is associated with high a level of safety and a short recovery period. Randomized control trials are needed for further evaluation of this SUI treatment.

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Conflicts of interest

There are no conflicts of interest.

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