

# A comparison of effectiveness and cosmetic outcome of two methods for ingrown toenail: partial nail matricectomy using CO<sub>2</sub> laser versus lateral nail fold excision

Hossein Kavoussi<sup>1✉</sup>, Ali Ebrahimi<sup>1</sup>, Mansour Rezaei<sup>2</sup>, Elias Salimi<sup>1</sup>, Harif Rashidian<sup>3</sup>, Reza Kavoussi<sup>4</sup>

<sup>1</sup>Hajdaie Dermatology Clinic, School of Medicine, Kermanshah University of Medical Sciences (KUMS), Kermanshah, Iran. <sup>2</sup>Health School, Family Health Research Center of Kermanshah University of Medical Sciences (KUMS), Kermanshah, Iran. <sup>3</sup>School of Medicine, Kermanshah University of Medical Sciences (KUMS), Kermanshah, Iran. <sup>4</sup>School of Medicine, Student Research Committee, Kermanshah University of Medical Sciences (KUMS), Kermanshah, Iran.

## Abstract

**Introduction:** Ingrown toenail (IGT) is a common nail disorder that causes discomfort and interferes with most activities. Most cases of IGT require procedural intervention. This study was performed to compare the treatment and cosmetic outcome of partial nail matricectomy (PNM) using CO<sub>2</sub> laser versus lateral nail fold excision (LNFE).

**Methods:** This interventional study was performed on 127 patients with IGT that were randomized into two groups. Demographic data, clinical characteristics, and treatment results were recorded in both groups.

**Results:** Sixty-two patients with a mean age of 28.23 ± 11.34 years were subjected to PNM and 65 patients with a mean age of 28.92 ± 9.63 years to LNFE. The PNM versus LNFE groups had cure rates of 85.5% versus 78.5%, fair cosmetic outcomes of 67.9% versus 84.0%, and infection rates of 4.8% versus 3.1%. The mean time of pain duration, return to daily activity, and return to work were nearly 3, 4, and 13 days, respectively, in both groups.

**Conclusions:** The treatment outcome was slightly better in the PNM group than in the LNFE group, and vice-versa for the cosmetic outcome. There were nearly similar outcomes in terms of the mean time of repair, pain duration, return to daily activity, and infection rate using both methods.

**Keywords:** ingrown toenail, treatment, partial nail matricectomy, CO<sub>2</sub> laser, lateral nail fold excision

Received: 4 May 2019 | Returned for modification: 29 July 2019 | Accepted: 6 January 2020

## Introduction

Ingrown toenail (IGT) is a very common disorder that may interfere with most daily activities and cause pain and discomfort (1–4).

Many modalities have been proposed for the treatment of IGT. However, most often IGT requires procedural treatment, especially in its moderate to severe condition, which includes surgical excision of the lateral nail fold and lateral matricectomy (5–15). The best treatment, in addition to the high cure rate, must consider the cosmetic aspect, preserve the toenail function, be inexpensive, have few postoperative complications, and consider return to work and daily activities at the right time (1, 2, 4, 12). A CO<sub>2</sub> laser is a medical device that is popular and available in the operating rooms of most outpatient clinics and is used for ablation of many benign, pre-malignant, and malignant skin lesions. This instrument is also appropriate for precise and fine dermatology procedures such as nail disorders (3, 4, 16).

This study was carried out to compare the treatment and cosmetic outcomes of partial nail matricectomy (PNM) using CO<sub>2</sub> laser and lateral nail fold excision (LNFE).

## Materials and methods

### Study design

This comparative interventional clinical study was performed on 127 patients with an IGT lasting over 3 years (2013–2016) at the Hajdaie Dermatology Clinic in Western Iran. Patients were clinically

diagnosed and enrolled in our study, but if there was any suspicion of other diagnoses, such as subungual exostosis, more assessments were carried out. Patients with onychomycosis and subungual exostosis as well as pregnant women were excluded from the study. The study was approved by the ethics committee of Kermanshah University of Medical Sciences and registered in the Iranian Registry of Clinical Trials (IRCT) database.

Before performing the procedure, surgical information was given to the participants and written informed consent was received from all of them. Patients were randomly divided into two groups. The first group was subjected to PNM using CO<sub>2</sub> laser and the second group to LNFE.

### Classification of ingrown toenail severity

The Mozena classification system (17) was used to determine the severity of IGT.

- Stage I: Inflammatory stage. Erythema, mild edema, and pain on pressure applied to the lateral nail fold. The nail fold does not extend over the nail plate.
- Stage IIa: Abscess stage. Increased pain, edema, erythema, hyperesthesia, oozing, and/or infection. The nail fold extends less than 3 mm over the nail plate.
- Stage IIb: Similar to stage IIa. The hypertrophic nail fold extends more than 3 mm over the nail plate.
- Stage III: Hypertrophic stage. Granulation tissue and chronic hypertrophy of the nail fold, which widely covers the lateral nail plate.

✉ Corresponding author: hkawosi@kums.ac.ir

- Stage IV: Distal hypertrophic stage. Serious chronic deformity of the toenail, both lateral and distal nail folds, hypertrophic tissue completely covering the lateral, medial, and distal nail plates.

### Treatment and cosmetic outcome

Our patients were followed over 24 months for treatment results and possible complications. IGT was considered cured when there was no granulation tissue, oozing, erythema, edema, or significant or persistent hyperesthesia or pain upon pressure applied to the lateral nail fold. A failure of treatment was considered when there were any of the signs and symptoms mentioned above.

Cosmetic outcomes were classified as follows: 1) fair cosmetic outcome when there was no or mild deformity in the nail fold or plate, or there was acceptable conformity between the nail fold and plate; 2) moderate cosmetic outcome when there was moderate deformity in the nail fold or plate or there was intermediate conformity between the nail fold and plate; and 3) poor cosmetic outcome when there was significant deformity in the nail fold or plate, or there was unacceptable conformity between the nail fold and plate.

### Surgical techniques

In both groups, if there was any infection, we prescribed appropriate preoperative antibiotics for 7 to 10 days. Three surgeons were involved in the treatment of our patients. For the great toenail involved, initial preparation with an antiseptic solution, nerve block anesthesia with 2% lidocaine without epinephrine, and fastening a tourniquet after approximately 15 minutes were performed in both groups.

In the PNM group (Fig. 1), first based on the severity of IGT grading, we demarcated a 2 to 3 mm strip on the lateral nail plate on the side involved and treated the demarcated line with CO<sub>2</sub> laser (MiXto SX®, Lasering, Italy).



**Figure 1** | a) patient with ingrown toenail; b) V-shaped excision in the angle of the proximal nail fold and the strip separated from the nail plate by laser therapy; c) induced strip in the nail plate removed and the horn portion of nail matrix destroyed by CO<sub>2</sub> laser; d) nylon suture used to approximate the lateral nail fold to the nail plate edges; e) postoperative site with patient's satisfaction.

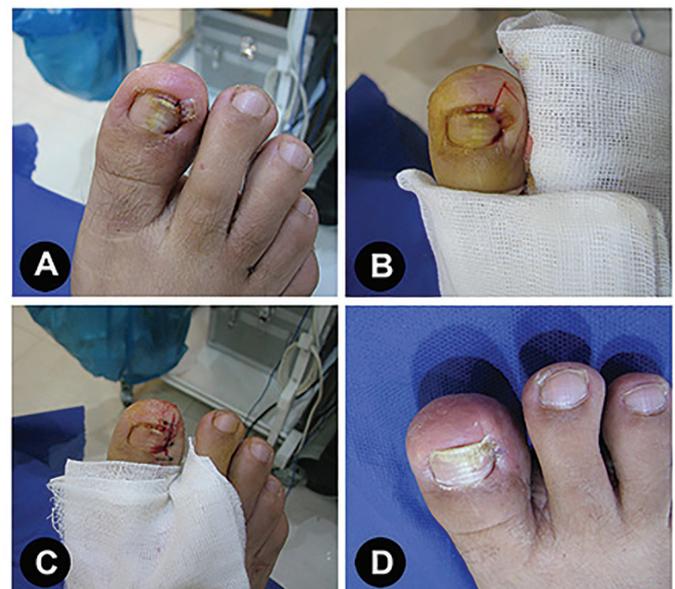
A deep V-shaped excision was made on the lateral side of the proximal nail fold; one arm was along the proximal end point of the laser-treated area and the other arm was placed on the corner

of the proximal nail fold. Then, the nail plate strip and V-shaped portion of the proximal nail fold were removed. In this situation, the lateral portion of the nail matrix that had to be destroyed was easily exposed and separated.

Finally, the exposed and separated lateral nail matrix underwent continuous CO<sub>2</sub> laser therapy using a power of 5 watts with a 1 mm spot size. The end point of the nail matrix laser therapy was exposure of the suprapariosteal layer of the distal phalanx. We moved the laser handpiece in a linear manner first in a back-and-forth direction and later in a left-and-right direction in the treated area during the procedure.

During laser destruction, particular consideration must be given to the vaporized lateral horn of the nail matrix. Further, in the presence of granulation tissues, this redundant tissue was removed and its base was treated with CO<sub>2</sub> laser. We used a nylon suture to approximate the edge of the lateral nail fold to the edge of the nail plate.

In the LNFE group (Fig. 2), a V-shaped excision was initially made in the lateral side of the proximal nail fold almost 3 mm from the edge of the nail. Care is needed to keep the nail matrix intact. Then, based on the severity of IGT, a fusiform excision was made on the side of the toe, extending distally to encompass all the granulation tissue, lateral nail-fold skin, and subcutaneous fat involved. The incision was extended superiorly to the end of the apex of the nail nearly 3 to 5 mm from the distal edge of the nail plate. Finally, the induced defect was closed with nylon suture.



**Figure 2** | a) patient with IGT and granulation tissue in the distal portion of the lateral nail fold; b) fusiform incision including the corner of the proximal and lateral nail fold and end of the nail apex; c) induced fusiform defect closed with nylon suture; d) complete cure with fair cosmetic outcome.

In both groups, the tourniquet was removed after the surgery and the surgical site was dressed with an antibiotic ointment and permeable gauze. To relieve the pain and prevent secondary infection, oral cephalixin was prescribed at a dose of 500 mg every 6 hours for 7 to 10 days.

### Statistical analysis

To compare the quantitative data between groups, an independent *t*-test or Mann-Whitney test was used. Analysis of qualitative data was conducted using a chi-square test and Fisher's exact

test. Significance level was considered 0.05 for all tests. Analysis of the data was performed using SPSS (version 12) software.

## Results

The PNM group included 62 patients, 30 males (48.4%) and 32 females (51.6%), with 87 cases of IGT. The mean ages of the PNM and LNFE groups were  $28.23 \pm 11.34$  and  $28.92 \pm 9.63$  years, respectively (Table 1). Table 1 shows the rate of previous treatment, tobacco smoking, sports activity, and severity of IGT, and the *p*-value of these variables, which did not differ significantly between the two groups. Complete cure by CO<sub>2</sub> laser was seen in 53 (85.5%) and 51 (78.5%) of patients in the PNM and LNFE groups, respectively (*p* = 0.860; Table 2).

In the PNM group, the cosmetic outcome was observed to be fair, intermediate, and poor in 36 (67.9%), 12 (22.6%), and five (9.4%) patients, respectively. In LNFE group, cosmetic outcome was found to be fair, intermediate, and poor in 42 (84.0%), six (12.0%), and two (4.0%) patients, respectively (*p* = 0.160; Table 2). Table 2 shows the mean time to return to work and daily activity, postoperative repair, duration of pain, and infection rate in both groups. In addition, there was no statistically significant difference between the two groups in the mean of the variables mentioned above. In the PNM patients, spicule formation after surgery

**Table 1 | Demographic and clinical characteristics of patients in the two groups.**

Variable	PNM with CO <sub>2</sub> laser	LNFE	<i>p</i> -value
Number of patients	62	65	
Number of IGT	87	79	
Mean age, years	$28.23 \pm 11.34$	$28.92 \pm 9.63$	0.709
Sex, <i>n</i> (%)			
Female	30 (48.4)	29 (44.6)	0.931
Male	32 (51.6)	36 (55.4)	
Severity of IGT, <i>n</i> (%)			
I	4 (6.5)	3 (4.6)	0.577
IIa	16 (25.8)	24 (36.9)	
IIb	25 (40.3)	26 (40.0)	
III	13 (21.0)	8 (12.3)	
IV	4 (6.5)	4 (6.2)	
Smoking, <i>n</i> (%)	7 (11.3)	12 (18.5)	0.257
Sport activity, <i>n</i> (%)	14 (22.6)	12 (18.5)	0.565
Previous treatment, <i>n</i> (%)	54 (87.1)	54 (83.1)	0.526
Location of IGT, <i>n</i> (%)			
Left lateral	34 (39.1)	32 (40.5)	
Left medial	10 (11.5)	10 (12.7)	
Right lateral	33 (37.9)	31 (39.2)	
Right medial	10 (11.5)	6 (7.6)	

PNM = partial nail matricectomy, LNFE = lateral nail fold excision, IGT = ingrown toenail.

**Table 2 | Treatment, cosmetic outcome, and complications after procedure in two groups.**

Variable	PNM with CO <sub>2</sub> laser	LNFE	<i>p</i> -value
Outcome of treatment, <i>n</i> (%)			
Cure	53 (85.5)	51 (78.5)	0.860
Spicule formation	3 (4.8)	0 (0.0)	
Failure	6 (9.7)	14 (21.5)	
Cosmetic outcome, <i>n</i> (%)			
Fair	36 (67.9)	42 (84.0)	0.160
Intermediate	12 (22.6)	6 (12.0)	
Poor	5 (9.4)	2 (4.0)	
Mean time to return of daily activity, days	$4.10 \pm 1.762$	$3.71 \pm 1.588$	0.207
Mean time to return of work, days	$13.16 \pm 3.020$	$12.29 \pm 1.958$	0.231
Mean time of repair, days	$13.00 \pm 2.489$	$12.18 \pm 2.157$	0.620
Mean time of pain duration, days	$3.66 \pm 2.111$	$3.20 \pm 1.734$	0.620
Postoperative infection, <i>n</i> (%)	3 (4.8)	2 (3.1)	0.485
Spicule formation, <i>n</i> (%)	3 (4.8)		

PNM = partial nail matricectomy, LNFE = lateral nail fold excision.

was seen in three (4.8%) cases (Table 2).

There was no correlation between the severity of IGT and treatment outcome (*p* = 0.093, *p* = 0.948) in both groups.

## Discussion

Our findings showed that the treatment outcome was slightly better in the PNM group with CO<sub>2</sub> laser than in the LNFE group, and vice-versa for the cosmetic outcome. The mean duration of return to work and daily activity, repair, and pain were also slightly shorter in the LNFE group than in the PNM group with CO<sub>2</sub> laser, but there was no statistically significant difference in terms of these variables between the two methods.

The treatment outcome with PNM by CO<sub>2</sub> laser (85.5%) in our patients is consistent with several studies (6–10), but the cure rate with LNFE (78.5%) is slightly lower than in previous studies (12, 13). We believe the variations in cure rate in different studies may be related to the severity of IGT in patients, the selection of different laser therapy parameters, differences in the amount of LNFE, and the surgeon's experience and skill.

Consistent with our results, many studies have shown satisfactory cosmetic outcomes for both methods (6–8, 12, 13). However, our study showed that the cosmetic outcome was slightly better in the LNFE group than in the PNM group with CO<sub>2</sub> laser. The severity of IGT, smoking, age and sex of the patients, previous treatment, difference in the amount of the LNFE involved, and nail matrix destruction affect the cosmetic results.

The mean durations of return to daily activity and return to work were nearly 4 and 13 days in both groups. Tada et al. (9) reported that treatment of IGT with CO<sub>2</sub> laser was significantly associated with an earlier return to daily life (about 3 days), which was similar to our findings. Preparation, an accurate procedure, and precise postoperative care are very important for early return to daily life activities.

Various studies (6–15) have indicated a range of 0% to 12.5% for postoperative infection in both methods. Our patients also showed a low infection rate after surgery in both groups. To reduce the postoperative infection rate, it is advisable to consider pre- and post-surgery care, including administering an appropriate antibiotic, reducing the surgical time, and minimizing manipulation during the operation (18, 19). The post-surgery infection rate was about 4%, and the mean durations of repair and postoperative pain were about 13 and 3 days, respectively, in both groups. Orenstein et al. (11) reported a postoperative infection rate

of 12.5%, mean time of wound healing of nearly 21 days, and pain duration of 5 days in both the PNM and LNFE groups. Because prolonged surgery time, smoking, older age, and inappropriate pre- and postoperative care increase the possibility of postoperative infection (18, 19), this condition is associated with prolonged postoperative pain and poor wound healing (20). We believe the differences in the results between our study and other studies in terms of repair time, postoperative infection rate, and pain period are related to the presence and absence of the aforementioned risk factors in patients.

Several studies have reported a range of 0.08 to 6% for spicule formation after PNM by CO<sub>2</sub> laser (6–10). Spicule formation was also seen in 4.8% of cases in our PNM group. We suggest full exposure of the nail matrix to be destroyed and that higher-power laser therapy, especially in the most lateral portion of the matrix, is crucial for preventing spicule formation after laser therapy.

## Conclusions

Treatment outcomes were slightly better in the PNM group with CO<sub>2</sub> laser than the LNFE group, and vice-versa was true for cosmetic outcome, but there was no statistically significant difference between the two methods. There were nearly similar outcomes in the terms of the mean durations of return to daily activity, repair, pain, and infection rate after surgery using both methods. The postoperative infection rate was slightly higher in the PNM group than in the LNFE group.

According to our findings, PNM with CO<sub>2</sub> laser is preferred in males, in athletes that specifically use their feet, and when there is involvement of both sides in one toe, especially in high-grade IGT. However, the LNFE procedure is preferred in females sensitive to the cosmetic aspect of the nail structure, especially in low-grade IGT.

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