

The Incidence of Hypertrophic Scarring and Keloid Formation Following Laser Tattoo Removal with a Quality-switched Nd:YAG Laser

^aWILLIAM KIRBY, DO, FAOCD; ^bDYLAN B. ALSTON, DO; ^cALAN H. CHEN, MD, FACS

^aLaserAway and Kirby Dermatology, Hermosa Beach, California; ^bUniversity of North Texas, Heights Dermatology and Aesthetic Center, Houston, Texas; ^cMidwestern University, Department of Plastic and Reconstructive Surgery, Downers Grove, Illinois

ABSTRACT

Background: Laser tattoo removal using quality switched technology is widely accepted as the standard of care. Determining the risk of hypertrophic scarring and keloid formation more precisely delineates the safety of this procedure and improves patient education regarding the risk of scarring. **Objective:** To investigate the incidence of hypertrophic scarring and keloids in a large patient population following treatment with a Q-switched neodymium-doped:yttrium-aluminum-garnet laser. **Design:** In November 2012, after a single Institutional Review Board approved retrospective chart review, 1,041 charts demonstrating greater than five treatment sessions were analyzed. All patients in the current retrospective study were treated under one study protocol. **Results:** An overall incidence of 0.28 percent (3/1,041) of patients receiving a minimum of five laser tattoo treatments with a Q-switched neodymium-doped:yttrium-aluminum-garnet laser developed clinical evidence of hypertrophic scarring. None of the 1,041 patients in this study developed keloid scars. **Conclusion:** With the Q-switched neodymium-doped:yttrium-aluminum-garnet laser utilizing accurate, protocol-based settings, the incidence of hypertrophic scarring following laser tattoo removal treatments was 0.28 percent (3/1,041) and the incidence of keloid scarring was 0.00 percent (0/1,041). (*J Clin Aesthet Dermatol.* 2016;9(5):43–47.)

Body tattooing has been manifest in cultures and civilizations since the earliest stages of humanity.¹ With the advent of newer technology, the myriad of designs, locations, and colors, individuals have found a unique way to self-express thoughts, emotions, and personality through body art. However, what has not changed is the tendency toward change and regret about the past. Despite the overwhelming prevalence and popularity of tattoos, the desire for laser tattoo removal is rapidly increasing.² The pressure to obtain and maintain employment combined with the desire for blank canvas has led people to laser tattoo removal as a means of dissociating from the past. Reasons behind tattoo removal include negative stigmata in professional environments, embarrassment, poor body image, and the need to seek a new career.³

Laser tattoo removal is not without risks. The primary

challenge is a thorough and accurate discussion regarding the risks and adverse effects associated with laser removal. Of chief concern to patients is the possibility of hypertrophic scars or keloids (Table 1). As a result, the authors set out to determine the incidence of hypertrophic scarring and keloids following treatment with a Q-switched neodymium-doped:yttrium-aluminum-garnet (Nd:YAG) laser.

METHODS

Data collection. Data was made available thorough single Institutional Review Board (IRB)-approved chart review of more than 5,000 charts, exceeding the prior largest study by 793 patients.⁴ Chart review from 2004 through 2012 (Table 2) included patient-reported data and clinician notes. Patient-reported data included age, gender, ethnicity, tattoo duration, and professional or amateur tattoo ink.

DISCLOSURE: The authors report no relevant conflicts of interest. This study was not funded or supported by any institution or company. No sponsors had a role in the design or conduct of this study, in the collection, analysis, and interpretation of data, or in the preparation or review of the manuscript.

ADDRESS CORRESPONDENCE TO: William Kirby, DO, FAOCD; E-mail: drwillkirby@hotmail.com

TABLE 1. Comparison of hypertrophic and keloid scars

HYPERTROPHIC SCAR	KELOID SCAR
Remains confined to the original site of trauma	Extends beyond the original site of trauma
Predilection for shoulders, knees, ankles, neck	Predilection for sternum, earlobes, cheeks, arms
Develops rapidly following injury	May develop months to years following trauma
Rapid growth phase followed by a regression	Persistence for years with no spontaneous regression
Low rate of recurrence following excision	High rate of recurrence following excision
No association with skin pigmentation	Higher association with skin pigmentation
High density of collagen and fibroblasts	Thick hyalinized collagen with mucin

TABLE 2. Patient demographics and select patient variables

	MINIMUM	MAXIMUM	AVERAGE	PROPORTION
Age (years)	18	84	31.06	
Treatment year	2004	2012	2007	
Gender				Male: 346 Female: 695
Tattoo Age (years)	0.11 (6/52wks)	53	8.60	
Skin type	Fitzpatrick I	Fitzpatrick VI	Fitzpatrick 2.73	
Tattoo size (inch ²)	1	50	3.46	
Total sessions	5	25	7.67	
Professional Ink				772/1041
Amateur Ink				231/1041
Combined Ink				33/1041
Cover-up Tattoo				97/1041
# of ink colors	1	9	1.8	

Experienced clinicians specializing in laser tattoo removal objectively assessed for the development of hypertrophic scars or keloids at each follow-up visit.

Inclusion and exclusion criteria. Study inclusion criteria included greater than five laser treatment sessions, age greater than 18, and tattoo duration greater than six weeks. Of the 5,000 reviewed charts, 1,041 met the aforementioned requirements; 3,248 charts were excluded for receiving only one treatment session and 711 were excluded for receiving 2 to 4 sessions. Patients receiving less than five total treatment sessions were excluded due to the inability to ensure adequate follow-up and to determine if cumulative laser sessions posed a higher risk for scarring. Five treatment sessions correlated highest with successful completion of laser tattoo removal and therefore provided greater confidence in determining the risk of scarring. Lastly, an interval of four weeks was required between treatments to allow for appropriate healing. All tattoos were re-evaluated at each subsequent visit for scarring. Treatment parameters consistent with standard protocols included use of a Q-switched Nd:YAG laser (1064nm wavelength, 10ns, 5Hz) in addition to 532nm via harmonic doubling for certain colors.

STATISTICAL ANALYSIS

Baseline characteristics of patient data including, but not limited to, age, gender, age of tattoo, and number of treatment sessions are summarized in Table 2. The range, mean, and proportions of relevant variables are presented therein (Table 2). Finally, the incidence rate, calculated as the number of new cases of hypertrophic scars or keloids over the total number of persons at risk for such scarring, was calculated.

RESULTS

At each follow-up visit, clinicians assessed for the presence of scarring and documented accordingly. Patients were instructed to contact the provider following any treatment if concerns for scarring, infection, or any other cosmetic alterations occurred. Of the 1,041 patients studied, none had a documented telephone or clinical contact note in the chart indicating a complication following their final treatment session at the time of this publication. It should be noted that of the 1,041 charts, only one was completed during 2012, 16 during 2011, and the remainder occurring between 2004 and 2010 suggesting long-term results are promising.

Following the analysis of the 1,041 total charts meeting study parameters, only 55 (5.3%) charts revealed some degree of tissue texture change, dyspigmentation, or scar. Of these 55 charts, 12 (21.8%) resulted from actual placement of the tattoo itself, an additional 23 (41.8%) self-reported scarring on survey intake forms whether from tattoo placement or from prior laser treatment at a different facility. Of the remaining charts, 13 (23.6%) self-reported “scar” formation specifically from prior outside tattoo removal attempts with devices including intense pulsed light, CO₂, continuous wave, and argon lasers.

Of the remaining seven patients, four (7.3%) reported uncertainty as to the etiology of their scar and only three (5.5%) charts documented clinically apparent hypertrophic scarring secondary to Nd:YAG laser tattoo removal performed entirely under the supervision of the clinicians (Table 3). Of note, there were zero (0/55) patients reporting or demonstrating keloids in this study and interestingly, a subset of 11 patients self-reported a prior history of keloid formation. A few of these patients (5) had clinically obvious lesions at both proximal and distal sites and subsequently experienced no such effects from laser treatment. Overall, this study demonstrated only three new cases of hypertrophic scarring at an incidence of 0.28 percent (3/1,041) receiving laser tattoo removal with a Q-switched Nd:YAG laser. The patient demographics of these three new cases are detailed in Table 3. Ethnicity of all patients is contrasted with the proportion of patients who experienced any type of abnormal scarring whether from actual tattoo placement or prior laser tattoo removal (Table 4).

It should be noted that 97 patients treated had layering of multiple tattoos known as “cover-ups.” Select case reports have proposed a higher propensity toward hypertrophic scarring and keloids when treating cover-up tattoos. The hypothesized mechanism is secondary to a higher density of tattoo ink causing laser energy to be more intensely absorbed producing excess thermal damage.⁵ Fortunately, no such adverse effects were noted in any of the 97 patients treated with cover-up tattoos and, therefore, may not suggest an increased risk for hypertrophic scars or keloids as was once thought.

Falling in line with epidemiologic estimates, the authors also found that hypertrophic scarring and keloids occurred most commonly in the third and fourth decades of life (25yrs, 39yrs, 36yrs).⁶

TABLE 3. Select statistical parameters of three patients experiencing hypertrophic scarring

	CASE 1	CASE 2	CASE 3
Age	39	36	25
Gender	Female	Female	Female
Ethnicity	Hispanic	Caucasian	Asian
Fitzpatrick skin type	IV	II	III
Tattoo location	Shoulder	Ankle	Shoulder
Tattoo size (inch ²)	4	2	3
Laser treatment sessions	10	10	12
Tattoo age (years)	15	18	8
Tattoo ink composition	Professional	Professional	Amateur
Tattoo ink colors	*Multiple	Black, red, green	Black
Cover-up tattoo	No	No	No

*Multiple colored tattoos defined as ≥4 different colors, one of which is black

TABLE 4. Ethnicity of all patients is contrasted with the proportion of patients who experienced any type of abnormal scarring

ETHNICITY OF PATIENTS RECEIVING LASER TATTOO REMOVAL	
African American	61 (5.8%)
Asian	91 (8.7%)
Caucasian	558 (53.6%)
Hispanic	290 (27.8%)
Other	41 (3.9%)
TOTAL	1,041
ETHNICITY OF PATIENTS REPORTING SCARRING FROM ANY SOURCE	
African American	4 (7.3%)
Asian	5 (9.1%)
Caucasian	29 (52.7%)
Hispanic	13 (23.6%)
Other	4 (7.3%)
TOTAL	55

TABLE 5. Incidence of abnormal scarring

AUTHOR(S)	LASER DEVICE	SAMPLE SIZE	INCIDENCE OF ABNORMAL SCARRING
Kilmer et al (1993) ²¹	1064nm Nd:YAG	14 professional 25 ruby resistant	Hypertrophic: 0% Keloid: none reported
Levine and Geronemus (1995) ¹⁸	1064nm Nd:YAG	48 unspecified	Hypertrophic: 2.1% Keloid: none reported
Ferguson and August (1996) ⁸	1064nm Nd:YAG	27 professional 221 amateur	Hypertrophic: 1.2% Keloid: none reported
Werner et al (1999) ¹⁷	1064nm Nd:YAG	25 professional 68 amateur	Hypertrophic: 0% Keloid: 0%
Ho et al* (2006) ²⁰	1064nm Nd:YAG	61 unspecified	Hypertrophic: 23.5%
Kirby and Alston† (2013)	1064nm Nd:YAG	771 professional 223 amateur 33 combined	Hypertrophic: 0.28% Keloid: 0%

*All patients treated were of Asian ethnicity with Fitzpatrick skin types III–V and received treatment for a 3mm spot size, with a 10Hz repeat rate, a pulse duration of 6 nanoseconds, and mean fluence, 4.2J/cm².

†Current study

DISCUSSION

Hypertrophic scars and keloids are seen in people of all races and skin types. The prevalence of keloid formation in the general population is relatively low, with a higher incidence in persons of color. Specifically, African Americans have demonstrated an incidence of 6 to 16 percent, likely a result of underlying genetic propensity toward scarring although successful treatment of darker pigmented patients with Q-switched Nd:YAG lasers have been repeatedly demonstrated.^{7–9} Furthermore, the overall incidence of hypertrophic scarring can be upwards of 91 percent following burn or thermal injuries speaking to the precise technology of selective photothermolysis. Since the process of selective photothermolysis allows for accurate targeting of tattoo ink while reducing nonspecific thermal damage to the endogenous chromophores like melanin and hemoglobin, the authors' estimate of abnormal scarring appears to be in line with other calculations using similar Q-switched lasers (Table 5).^{4,10–12} As a result, the authors found the overall incidence of hypertrophic scarring and keloids following laser tattoo removal to be less than one percent in patients receiving a minimum of five laser treatments. Interestingly, as noted in this study, none of the 38 treated patients with Fitzpatrick skin types V or VI experienced hypertrophic scars or keloids.

It should be noted that the hypertrophic scars in the three aforementioned patients treated with the Nd:YAG laser represented the earliest stages of scarring and did not denote extensive or cosmetically disfiguring lesions. As a result of these early changes, supervising clinicians agreed to halt further treatment and assess for lesional regression.

Recently, Jalian et al¹³ outlined the most common causes of legal action, claims, and injuries related to various cutaneous laser surgeries (not limited to tattoo removal) from 1985 to 2012. It was found that second only to thermal burns, “scarring” which included hypertrophic scars and keloids comprised nearly 39 percent of injuries sustained secondary to laser treatments from various devices. As a result, the leading cause of legal action in medical malpractice claims was cited as a lack of informed consent comprising 30.5 percent, with fraud trailing as a distant second at 8.6 percent. The significance of these findings lies in the strikingly important discussion on potential adverse effects and patient-practitioner expectations. The incidence of hypertrophic scars and keloids presented in this paper allows for candid discussion and appropriate risk assessment for patients, thus leading to higher patient satisfaction and potentially lower malpractice claims.

In conclusion, it is likely that the anecdotal rumors of hypertrophic scarring and keloid formation in association with tattoo removal is likely secondary to the selection of inappropriate treatment devices, aggressive protocols, poor patient aftercare, or lastly, patient confusion on the definitions and differences between tissue texture changes, dyschromia, hypertrophic scarring, and keloids.

As in this study, the incidence of these unwanted side effects (0.28%) is lower than the authors anticipated. The ability to quantify the incidence of hypertrophic scars and keloids now makes the appropriate pre-treatment counseling regarding practical expectations and realistic and theoretical adverse outcomes more tangible and instills patient confidence in the treating health care practitioner.

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