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Safety and Efficacy of Long-pulsed Nd:YAG Laser for the Treatment of Keloids – A Prospective Study of 39 Keloids

Venkataram Mysore, Madhulika Mhatre
Venkat Charmalaya Centre for Advanced Dermatology, Bangalore, India

ABSTRACT

Introduction: Effective keloid management is still difficult despite many recent modalities being introduced. Lasers such as pulse dye lasers and Nd:YAG lasers have been tried for the treatment of keloids due to their ability to cause capillary destruction and also collagenase induction, but adequate data are lacking.

Objective: To assess the efficacy and safety of long-pulsed Nd:YAG laser in the treatment of keloids.

Material and methods: We conducted a prospective study of 39 hypertrophic scars (of less than 6 months duration) and keloids (of more than 6 months duration) in 19 patients who were treated with a long-pulsed (1064 nm) Nd:YAG laser for 3 sessions at three-week intervals. At each visit, the treatment effectiveness was measured by the Vancouver scar score (VSS) on the basis of vascularity, pigmentation, pliability and height. Therapeutic effectiveness criteria (TEC) and patient satisfaction scores (PSS) were also recorded. Data was statistically analyzed with the help of the One-way ANNOVA test.

Results: The total improvement in the VSS was 29.6% at the end of the study. There was no significant difference in improvement based on site-wise comparison. With the PSS, 18 out of 29 patients recorded an improvement of 30-50%. With the TEC, 21 showed excellent improvement followed by 13 having effective and none having inefficient improvement. Lesions of less than 6 months duration showed statistically significant improvement in terms of vascularity, pliability, height and total score ($P < 0.003$); on the other hand, keloids of more than 6 months duration showed statistically significant improvement in terms of vascularity, pliability and total score ($P < 0.0001$), but not in height. Comparing between both subgroups, the percent improvement was greater in keloids of less than 6 months duration (17.5% in vascularity and 33% in height, 10.3% in total score). Side-effects observed were transient; post-procedure pain occurred in three patients and hypopigmentation in one patient.

Conclusion: Long-pulsed Nd:YAG laser is effective and safe in the treatment of keloids and serves as a new emerging tool for treatment, with significant improvement seen in Vascularity, Pliability, Height and Total score parameters, particularly in early scars. Though complete resolution was not seen in any patient, this modality may be used as an adjunct to other existing traditional treatments as is easy to perform and free from significant side effects. Treating keloids early is of high importance for achieving better results. A larger study with a longer follow up is recommended.

Key words: Keloids, hypertrophic scars, Nd:YAG laser.

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I. INTRODUCTION

Hypertrophic scars and keloids are the major forms of excessive cutaneous scarring that occur in predisposed individuals following skin injury [1, 2]. Despite a remarkable increase in knowledge regarding wound healing and advances in keloid and hypertrophic scar (HS) treatment, desirable results have largely remained elusive. The treatment armamentarium for these lesions has ranged from oral and topical to procedural treatments, but with variable results and recurrences. Because of the complex pathogenesis and variability in responsiveness, it is very difficult to treat keloids, resulting in a high recurrence rate regardless of therapy – and to date, no effective treatment exists for permanent keloid removal. There are no specific protocols for the treatment of hypertrophic scars and keloids, and the treatment has to be individualized according to the distribution, size, thickness, and consistency of the lesions and associated inflammation.

Lasers provide a non-invasive, safe, painless and a well-tolerated modality. Despite their multi-functional potential, they are not aptly utilized. Different types of lasers, such as ablative lasers and vascular lasers, have been tried since the 1980's. However, as a modality, lasers have generally disappointed by providing only variable results.

Currently there has been interest generated in use of long-pulse Nd:YAG laser for the treatment of keloids

because of its effects on both dermal vasculature and metalloproteinase. The aim of the current study was to determine the safety and efficacy of long-pulse Nd:YAG laser in the treatment of keloids and hypertrophic scars.

II. MATERIALS AND METHODS

This was a prospective study of 39 keloids in 19 patients who were treated with a long-pulsed (1064 nm) Nd:YAG laser from Fotona® (using Variable Square pulse technology with top hat beam profile) [3] for 3 sessions at three-week intervals after obtaining proper written and informed consent and digital photographs. The treatment parameters used were: 3 mm spot size diameter; 100-170 J/cm2 fluence; 15-20 ms exposure time per pulse; and 1 Hz repetition rate. Cooling was done before, during and after the procedure with a Zimmer Cryo6®. At each subsequent visit, the efficacy of the treatment was evaluated both subjectively and objectively. Clinical improvement was assessed by the Vancouver scar scale (VSS) on the basis of vascularity, pigmentation, pliability and height (Table 1).The summation of the scores of these 4 parameters constitutes the Total Vancouver scar Score. Therapeutic effectiveness criteria (TEC) (Table 2) and patient satisfaction score (PSS) and side effects, if any, were also recorded at each subsequent visit. For evaluation of results, the patients were further divided into two subgroups, based on the duration of scars, into those with lesions of less than 6 months duration and those with more than 6 months to see if the duration of the lesions had any role to play in the treatment response.

a) Inclusion Criteria:

All patients with keloids who did not respond to other modalities or who willingly wanted to opt for laser treatment as a first choice

b) Exclusion Criteria:

- Pregnant or lactating females
- Children less than 12 yrs.
- Patients on other modalities of treatment

Table 1: Vancouver Scar Scale [4]

PIGMENTATION:	VASCULARITY:
0-normal color 1- hypopigmented 2- hyperpigmented	0-normal, 1-pink 2- red 3- purple
PLIABILITY:	**HEIGHT:**
0-Normal 1-Supple (flexible with minimum resistance) 2-Yielding (giving way to pressure) 3-Firm (solid/inflexible, not easily moved) 4-Banding (rope like) 5-Contracture present	0- normal (flat), 1-<2mm 2->2mm and <5mm 3->5mm

Table 2: Therapeutic Effectiveness Criteria [5][6]

Excellence	No noticeable scar or scar apparent with cosmetically satisfactory result
Effectiveness	Obvious improvement, but scar with unsatisfactory cosmetic appearance
Inefficiency	Disfiguring scar as large, or larger, than prior to treatment.

III. RESULTS

All the keloids treated showed improvement in all 4 parameters of the VSS, with successive sessions (Figure 1). Improvement in VSS was seen mainly in vascularity and pliability, with some improvement in pigmentation and height. The total score percentage improvement noted between the first and last visit was 29.6% (Figure 2). Further, on comparing the two subgroups on the basis of the duration of lesions, the scars of less than 6 months group showed good improvement in terms of vascularity, pliability, height and total score, whereas the other subgroup showed statistically significant improvement in vascularity, pliability and total score only. On statistical comparison between both the groups, the early keloid group showed statistically significant improvement in terms of vascularity, height and total score when compared to the late keloids. Data at the beginning of treatment was statistically non-significant and comparable. At the end of 3 treatment sessions, there was statistically significant improvement in vascularity and height in the early keloid group (Figures 3, 4, 5).

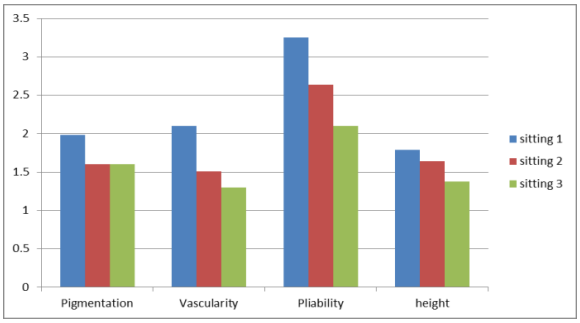
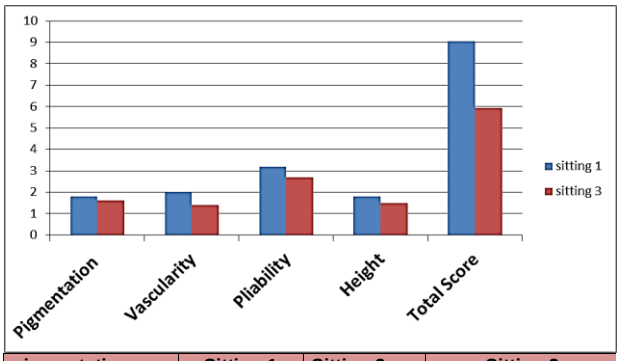


Fig. 1: Session-wise improvement

Fig. 2: Percentage improvement in Total Vancouver Scar Score after 3 sittings



pigmentation	Sitting 1	Sitting 2	Sitting 3
Mean	1.88	1.66	1.66
SD	0.47	0.59	0.59
ANNOVA test	f-value	P-Value	Difference is
One way ANNOVA	0.957	0.3906	Not significant

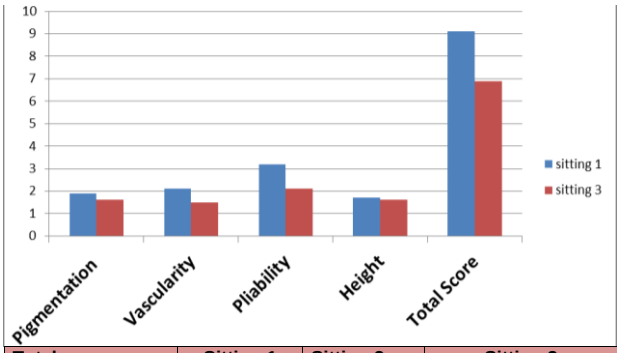
vascularity	Sitting 1	Sitting 2	Sitting 3
Mean	2.05	1.44	1.16
SD	0.41	0.61	0.51
ANNOVA test	f-value	P-Value	Difference is
One way ANNOVA	13.668	<.0001	Extremely significant

pliability	Sitting 1	Sitting 2	Sitting 3
Mean	3.27	2.72	2
SD	0.82	0.669	0.68
ANNOVA test	f-value	P-Value	Difference is
One way ANNOVA	13.84	<0.0001	Extremely significant

height	Sitting 1	Sitting 2	Sitting 3
Mean	1.83	1.5	1.11
SD	0.51	0,51	0.75
ANNOVA test	f-value	P-Value	Difference is
One way ANNOVA	6.38	0.003	Very significant

Total score	Sitting 1	Sitting 2	Sitting 3
Mean	9.05	7.33	5.94
SD	1.25	1.45	1.58
ANNOVA test	f-value	P-Value	Difference is
One way ANNOVA	21.05	<0.0001	Extremely significant

Fig. 3: Pre-treatment vs. post-treatment in < 6m keloids



Total score	Sitting 1	Sitting 2	Sitting 3
Mean	9.14	7.66	6.95
SD	1.15	1.31	1.24
ANNOVA test	f-value	P-Value	Difference is
One way ANNOVA	7.05	<0.0001	Extremely significant

pliability	Sitting 1	Sitting 2	Sitting 3
Mean	3.23	2.57	2.19
SD	0.70	0.67	0.51
ANNOVA test	f-value	P-Value	Difference is
One way ANNOVA	14.64	<0.0001	Extremely significant

vascularir	Sitting 1	Sitting 2	Sitting 3
Mean	2.14	1.57	1.52
SD	0.47	0.50	0.51
ANNOVA test	f-value	P-Value	Difference is
One way ANNOVA	10.00	0.0002	Extremely significant

height	Sitting 1	Sitting 2	Sitting 3
Mean	1.76	1.76	1.61
SD	0.62	0.62	0.58
ANNOVA test	f-value	P-Value	Difference is
One way ANNOVA	0.37	0.68	Not significant

pignmentation	Sitting 1	Sitting 2	Sitting 3
Mean	1.95	1.71	1.61
SD	0.21	0.56	0.66
ANNOVA test	f-value	P-Value	Difference is
One way ANNOVA	2.29	0.109	Not significant

Fig. 4: Pre-treatment vs. post-treatment in >6m keloids

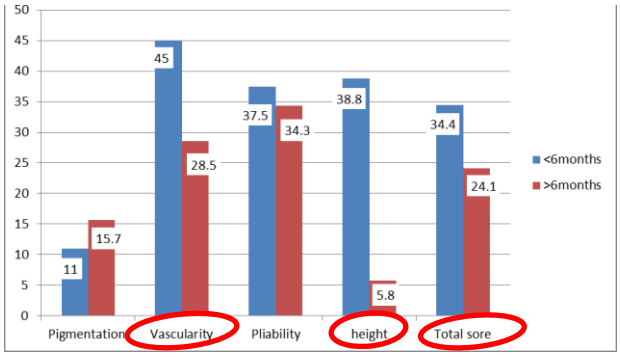


Fig. 5: Comparison of percentage improvement in the two groups

Site-wise assessment of response did not show any statistical correlation with the treatment effectiveness. This was not in accordance with a study by Yan Daojin, which showed better response in keloids over non-tension areas [7] (Figure 6).

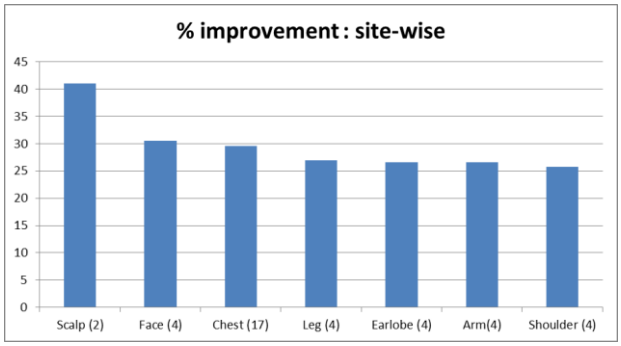


Fig. 6: Site-wise improvement

On the therapeutic effectiveness scale, no patient showed ineffectiveness in response. Most of the late keloids showed effective response, while the majority of the early keloids showed excellent response (Figure 7). A similar change in therapeutic effectiveness was also reported by Sherman R and Abergel RP in independent studies, in which no patients showed an ineffective response [8, 9].

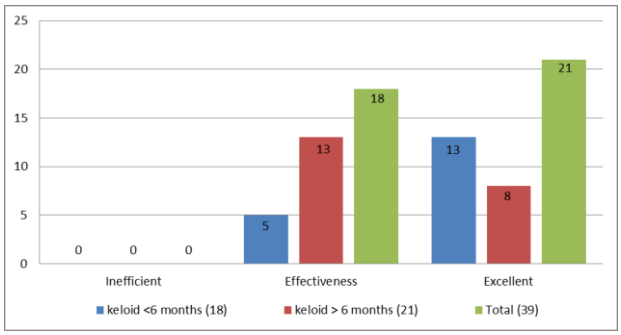


Figure 7: Therapeutic effectiveness criteria

On subjective assessment by patient satisfaction score, a majority of the patients showed a score of 30 to 50% improvement (19/39 keloids), with 5 patients having a minimal 0-10% score.

No major side effects were observed in the study which would warrant discontinuation of therapy. The side effects observed were mild and transient with 3 keloids showing transient pain, hypopigmentation in one and acneiform eruptions in another (5/39). Acneiform eruption was attributed to the overuse of topical steroid application post the laser treatment (Figure 8).

Fig. 8: Side-effects observed: A) showing hyperpigmentation and B) showing acneiform eruption

Figure 9: Before and after treatments

A six-month follow up of the patients did not reveal any recurrences.

IV. DISCUSSION

Even though several modalities of treatment are currently available for the treatment of keloids, none are effective in all patients, and to complicate the issue there are no standard treatment guidelines for the same.

Table 3: Treatment options for keloids and hypertrophic scars (Mutalik S. Treatment of Keloids and hypertrophic scars. Indian J Dermatol Venereol Leprol 2005;71:3-8)

1. Pressure garments
2. Radiation:
    a. Superficial X-rays
    b. Electron beam therapy
    c. Interstitial radiotherapy
3. Excision
4. Intralesional injections
    a. Triamcinolone
    b. 5-Fluorouracil
    c. Bleomycin
    d. Interferon alpha
5. Cryotherapy
6. Silicone gel dressings
7. Lasers
    a. Carbon dioxide laser
    b. Erbium-YAG laser
    c. Pulsed dye laser

Current emphasis is to develop new therapeutic modalities by using the versatile properties of lasers, targeting the pathophysiology of keloids at various stages.

To date, a number of studies have been undertaken for the use of lasers in keloid management, dating back to the mid-1980s [10], but they were confined mainly to PDL and CO2 lasers, either used alone or in combination with other established modalities [11, 12].

After a thorough search of available literature on the subject, studies on the use of long-pulsed Nd:YAG lasers for keloid treatment were scarce. That is where the current study tries to bridge the gap.

The basis for choosing the Nd:YAG laser is because of its action on collagen and vessels, its non-invasive nature, safety profile and high degree of tolerability. It is a versatile laser capable of acting on different components such as vessels, pigment and collagen.

This laser has a better vascular effect then PDL due to its deeper penetration. Also, the energy is weakly absorbed by melanin and better absorbed by blood vessels, thus making it safer for the Indian skin type. Lasers act on keloids by the principle of heat generation, which initiates a cascade of events leading to an increase in vascular permeability, increased MMP production and collagen fiber fascicle decomposition [13]. This stimulation of MMP was first documented by Kuo et al [14]. Due to greater depth of penetration of the long-pulsed Nd:YAG laser, this effect is more pronounced and more effective in comparison with a short-wavelength laser like the PDL. Secondly, the Nd:YAG laser also induces changes in the collagen bearing tissue at depths of 500 to 1000 um. The depth of heat attained by it reaches the mid-dermis; the level from where keloids generate. Other advantages with Nd:YAG is that it is weekly absorbed by melanin and water, thus increasing its overall safety profile [12].

The study by Satoshi et al. is by far the most comprehensive data available on Nd:YAG lasers for keloid treatment, and the results are comparable to the current study. In his study, the average total scar assessment score fell from 9.86 to 6.34. Of the 22 patients studied, 8 exhibited a clear reduction in the size of their lesions (<90% of the original area), 10 had a slight reduction (90% to 95% of the original area), and 4 showed no change (>95% of the original area). Our study did not show this dramatic reduction since the numbers of sessions in our study were only three. We recognize this as a limitation and agree that a larger number of sessions would probably be needed to produce a greater response.

Another study by M.H. El-Tonsy et al. also showed the laser group responding with very good results in 28% of patients, which was comparable with the current study [15]. The author also divided the keloids into two subgroups of less than one year and more than a year, and found that keloids of less than one year responded better to treatment This study endorsed the findings in our study that the earlier the treatment, the better the results.

Complications observed in our study were transient and minimal, proving the laser's safety and efficacy in the Indian population.

V. CONCLUSIONS

Long-pulse Nd:YAG laser is effective in treating keloids and hypertrophic scars. Lesions with less than 6 months duration respond better in terms of clinical improvement. This clinical evaluation found that Nd:YAG laser treatment is effective regardless of patient's age, the origin and multiplicity of scarring, the location of the scar(s), or the onset of the scar.

However, the effect is neither complete nor

dramatic. Though complete resolution was not seen in any patient, with more treatment sessions, a better response could be expected

This study will pave the way for future comparison of Nd:YAG with established modalities like ILS and 5-FU therapy to know the true place of this new modality of treatment in the therapeutic ladder for keloids.

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