Int Ophthalmol
https://doi.org/10.1007/s10792-018-0923-1

ORIGINAL PAPER

Nd:YAG laser for epithelial ingrowth after laser in situ keratomileusis

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Received: 28 November 2017 / Accepted: 13 April 2018

Abstract
Purpose To evaluate the efficacy of neodymium:yttrium–aluminum–garnet (Nd:YAG) laser for treatment of epithelial ingrowth after laser in situ keratomileusis (LASIK).
Patients and methods Fifty-eight patients with epithelial ingrowth presented to Sohag refractive center, Sohag, Egypt, between January 2015 and March 2017. Only 41 patients (18 females and 23 males, mean age: 33.4 years) involving 41 eyes were indicated for treatment by Nd:YAG laser as the rest of the eyes were only under observation. Patients with epithelial ingrowth were recognized at a mean of 6 months after primary LASIK procedure (range: 2–16 months). Four eyes had undergone previous LASIK enhancements. Four eyes had the epithelial ingrowth removed by flap lift and scrapping. The mean intensity of the spots used was 0.8 mJ with variable number of shots depending on the size and density of the epithelial ingrowth area. Twenty-eight eyes showed complete regression after one session, while the rest necessitated 2–3 sessions for complete resolution. Mean follow-up period was 8 months (range 5–12 months).
Results Epithelial ingrowth was treated successfully in all 41 eyes. The uncorrected visual acuities were 20/20, and there was no evidence of recurrent epithelial ingrowth after 6 months with no complications reported.
Conclusion YAG laser is a simple, effective outpatient procedure for the management of epithelial ingrowth after LASIK.

Keywords Nd:YAG · Epithelial ingrowth · Laser in situ keratomileusis

Introduction

Flap-related complications after laser in situ keratomileusis (LASIK) are not uncommon [1]. Epithelial ingrowth after microkeratome flap creation has been reported to occur in 0–20% of cases [2, 3] with decreasing incidence after the advent of femtosecond laser for the creation of the corneal flap possibly due to its vertical cut [4, 5]. The mechanism of formation of epithelial ingrowth is either corneal epithelium invasion of the interface at the flap edge, mostly due to bad coadaptation of the edge or planting of epithelial cells spread during surgery [2].

Epithelial ingrowth can disappear, remain stationary or worsen by time due to keratolysis of the overlying stroma [6]. Thus, surgical removal is required essentially in clinically significant epithelial

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Published online: 04 May 2018

ingrowth [3] where it extends into the visual axis, affecting the quality of vision by nighttime glare, irregular astigmatism or causing foreign body sensation or leading to the more devastating corneal melt [7].

Risk factors for developing epithelial ingrowth included: recurrent corneal erosions, corneal basement membrane epithelial dystrophy intraoperative epithelial defect, corneal flap integrity problems, hyperopic corrections and diabetes mellitus [8]. Several maneuvers have been suggested for removal such as: flap lifting and manual debridement of the epithelial sheets with adjunctive sutures with or without the application of ethanol or anti-metabolites, phototherapeutic keratectomy, the use of tissue adhesives and amniotic membrane [9–13]. In 2008, Ayala et al. [14] reported the use of Nd:YAG laser to eliminate epithelial ingrowth.

The aim of our study was to evaluate Nd:YAG for the management of epithelial ingrowth after LASIK as a noninvasive, simple and outpatient procedure.

Patients and methods

This is a retrospective chart review of fifty-eight patients with epithelial ingrowth presented to Sohag refractive center, Sohag, Egypt, between January 2015 and March 2017. Only 41 eyes involving 41 patients (18 females and 23 males, mean age: 28.6 years) were indicated for treatment by Nd:YAG laser. Seventeen eyes with epithelial ingrowth were excluded from the beginning of the study as the lesions were too small < 1 mm or did not show visual manifestations or did not progress on follow-up visits.

All eyes had LASIK procedures by the authors of this paper using the same technique. The corneal flap was cut by the Moria M2 microkeratome (Moria, Antony, France). VISX S4 IR excimer laser system was used in all cases. There were no reported complications in the primary procedure. Patients with epithelial ingrowth were recognized at a mean of 6 months after LASIK (range: 2–16 months). Four eyes had undergone previous LASIK enhancements within 3 months of the primary procedure. Four eyes had the epithelial ingrowth removed by flap lift and scrapping with the application of mitomycin C 0.02%. These four eyes were managed as stated before introducing YAG laser in our protocol of management.

Inclusion criteria were as follows: on slit-lamp examination, epithelial ingrowth appeared as epithelial pearls in the interface or confluent whitish opacity either centrally or peripherally. These lesions would be either encroaching on the pupil or causing irritative symptoms such as glare, halos or dryness or increasing in size on follow-up visits.

Half of the cases were isolated nests of ingrowth, and the other half were continuous sheets growing from the flap edge. Patients' symptoms ranged from affection of BCVA in 28 eyes (68.3%), while 13 eyes (31.7%) had irritative symptoms as glare and dryness.

None of our patients were diabetic. The 41 patients enrolled in this study were with a majority of myopic refraction (37 patients). None had flap complications, while only three eyes showed epithelial loss intraoperative.

Neodymium:yttrium–aluminum–garnet laser technique: Topical anesthetic drop of benoxinate hydrochloride 0.4% was applied to the eye at concern. Abraham capsulotomy lens (Ocular Instruments, Washington, USA) was used to stabilize the eye. The Nd:YAG laser (Visulas® YAG III, Carl Zeiss Ophthalmic System Inc.) was used which employs infrared light at a wavelength of 1064 nm. Spot size used was 8 μm which gives rise to small vacuoles (Fig. 1b) that may join together to produce large vacuoles leading to the disruption of nearby tissue. The power used was 0.8 mJ aiming in the beginning at the track of the implantation if there was a visible one. Then, shots were applied centrally and moving centrifugally to make the air bubbles coalesce. Each shot was at the edge of the adjacent vacuole formed by the previous one until the whole area of the ingrowth was treated. The number of spots and sessions varied according to the size and density of the epithelial ingrowth. The power was limited to 0.8 mJ, and number of shots limited to 20 for fear of corneal melt. The sessions' interval was 1 week apart. Postoperative treatment included fluorometholone eyedrops three times daily for a week.

Informed consent was obtained from all patients after explaining the treatment plan. The study adhered to the tenants of Helsinki Declaration and was approved by the Ethical Committee of the Faculty of Medicine, Sohag University.

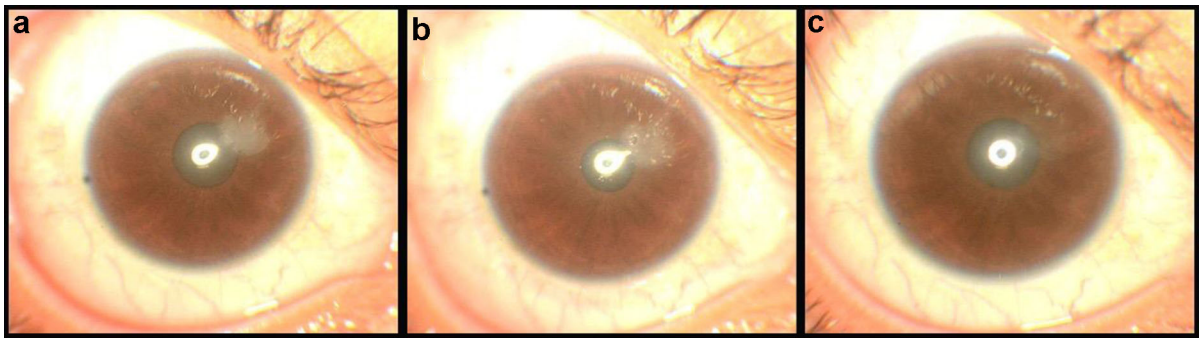

Fig. 1 **a** Pre-treatment; **b** air vacuole immediately after YAG session; **c** post-treatment by YAG laser for epithelial ingrowth

Results

Forty-one patients (18 females and 23 males, mean age: 28.6 years(involving 41 eyes (21 right, 20 left) were enrolled in this study. These patients were seen at a mean of 6 months after LASIK (range: 2–16 months). Four eyes (9.6%) had undergone one enhancement. The epithelial ingrowth was primarily peripheral in 35 eyes (85.4%) and primarily central in 6 eyes (14.6%). Four eyes (9.6%) had undergone one previous removal of epithelial ingrowth.

Mean uncorrected visual acuity (UCVA) improved from 20/80 (range: 20/30 to 20/100) preoperatively to 20/30 (range: 20/20 to 20/40) at the last follow-up. Mean best-corrected visual acuity (BCVA) improved from 20/60 (range: 20/25 to 20/80) preoperatively to 20/250 (range: 20/20 to 20/30) at the last follow-up. In the 28 eyes whose vision was affected, 15 eyes gained one line, 8 eyes gained 2 lines, and 5 gained 3 lines. No eye lost any lines of BCVA.

Twenty-eight eyes (68.3%) showed complete regression after one session, while the rest necessitated 2–3 sessions for complete resolution (9 eyes needed 2 sessions and 4 eyes needed 3 sessions) (Figs. 1, 2). Mean follow-up period was 8 months (range 5–12 months). Through the follow-up period, no recurrence was detected. No early or late complications were reported during the follow-up such as corneal melt nor scarring.

Discussion

The lines of management of epithelial ingrowth have been diverse with no consensus about the ideal maneuver until now. There have been some reports of mere follow-up with no intervention due to the surgical risks of an increased incidence of epithelialization, irregular astigmatism and tearing of the corneal flap [1, 15, 16]. The surgical interventions for removing epithelial ingrowth ranged from manual scrapping alone [17] or the addition of laser (phototherapeutic keratotomy [PTK]) [12] or a chemical material such as alcohol [10] or mitomycin C or adding a mechanical barrier as amniotic membrane [13] or fibrin glue [11] or suturing of the flap [18]. Some advanced cases would require penetrating keratoplasty [8]. All these maneuvers are invasive and do not ensure prevention of recurrence [14].

Epithelial ingrowth has been classified into three grades which was proposed by Probst and Machat [19]: Grade 1, ingrowth limited to within 2.0 mm of the flap edge with no associated visual changes; Grade 2, ingrowth thickness at least 2.0 mm from the flap edge but with a normal edge anatomy; and Grade 3, pronounced ingrowth of > 2.0 mm from the flap edge, often with anatomic abnormalities in the edge itself.

While observation is warranted in Grade 1, intervention is needed once visual acuity or flap abnormalities represent themselves which is the rule we applied for choosing patients for this procedure.

In the present study, there were no obvious risk factors for the occurrence of epithelial ingrowth such as buttonhole of the flap, trauma. Epithelial erosions occurred only in four cases. Also most cases presented with a mean of 6 months after the primary LASIK procedure which is a late presentation as reported by Todani et al. [20].

Although Nd:YAG laser has been vastly used in ophthalmology as for posterior capsular opacification, peripheral iridotomies and vitreolysis, its application in the field of corneal surgery was very sparse as in

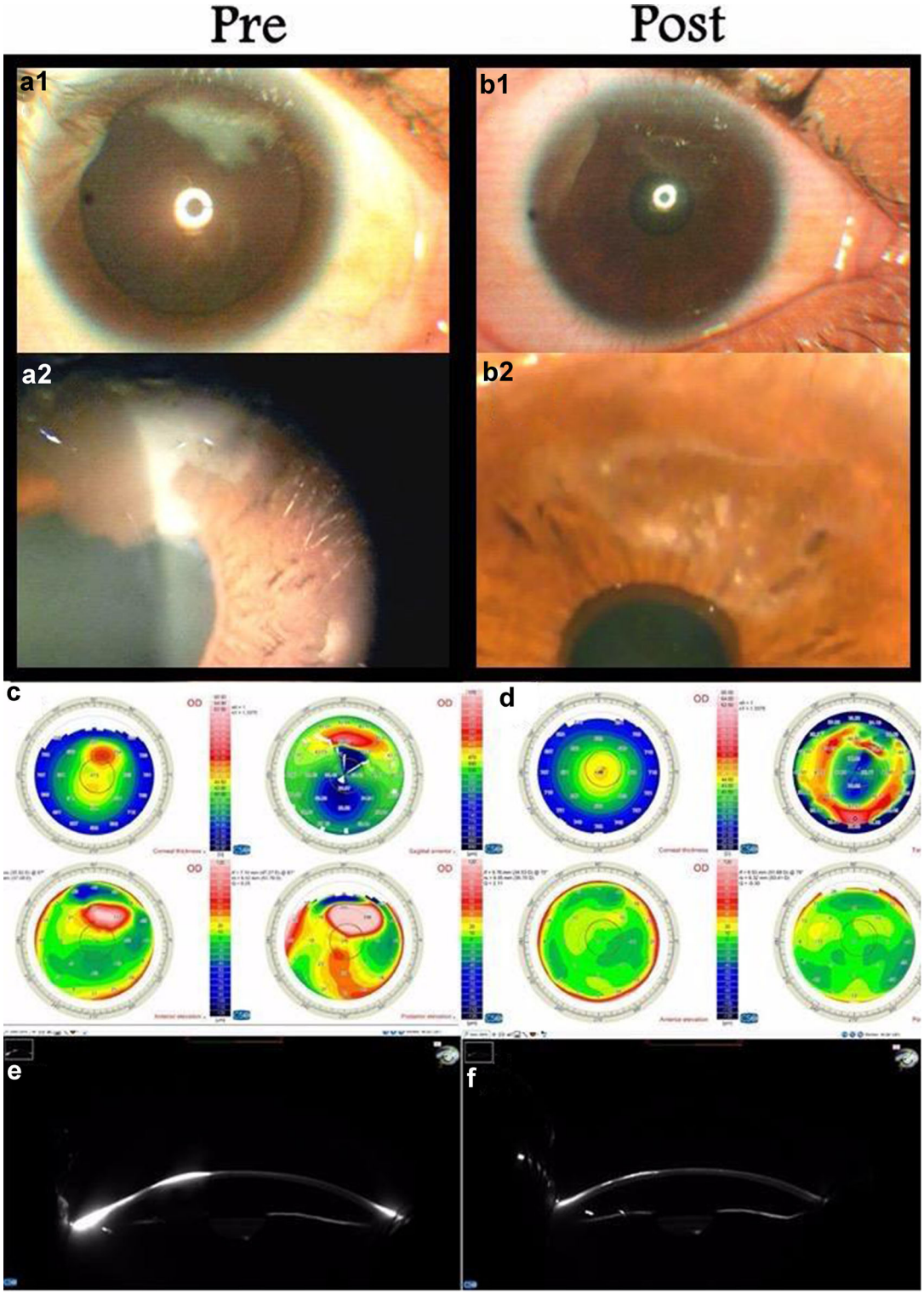

Fig. 2 **a1** Large epithelial ingrowth under the hinge; **a2** magnified image of the lesion; **b1** post-YAG treatment with the disappearance of the lesion; **b2** magnified image of the lesion; **c**, **d** pre- and post-treatment topography maps; **e**, **f** Scheimpflug image of the cornea pre- and post-treatment

crystalline infectious keratopathy [21] and recurrent corneal erosions [22].

The use of Nd:YAG laser treatment for epithelial ingrowth has been reported in a small number of studies on a small number of cases with a cure rate that reached up to 100% of patients [23]. Yet some would propose that YAG laser is only effective in cases that were not significantly advanced [24]. In the current study, we aim to report the results of Nd:YAG laser for treatment of both small epithelial nests and large pearly white lesions of epithelial ingrowth in a large number of patients.

Fracture of Bowman's membrane and epithelial defect or flap melt [25] are some reported Nd:YAG laser complications [26]. Yet we did not encounter any complications and no recurrence over an 8-month follow-up. Some reports encountered flap perforation with breakthrough of the ingrowth and flap melt which did not occur in any of our cases [27].

We can conclude that our study would put Nd:YAG laser at the top of our choice for treating epithelial ingrowth after LASIK procedure. It proved to be effective in large dense epithelial ingrowth with no recurrence over a follow-up period of a mean of 8 months. In addition, it offers a simple safe, time sparing outpatient maneuver with no flap lift as well as cost-effective.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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