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Fractional, Nonablative Q-switched 1,064-nm Neodymium YAG Laser to Rejuvenate Photoaged Skin: A Pilot Case Series

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ABSTRACT

Background: Scientific research in the field of energy-based and light-based procedures made it possible to develop a very new and innovative generation of lasers that combine the benefit of a nonablative and a fractional laser device, promising skin rejuvenation without harming the epidermis. With this pilot case series, we performed one of the first systematic reports evaluating efficacy and safety of the fractional, nonablative Q-switched 1,064-nm neodymium-doped yttrium aluminum garnet (Nd:YAG) laser device in the treatment of rhytides of the face, neck, and chest.

Methods: Seven healthy female subjects (mean ± standard deviation age, 53.8 ± 10.0 years) with visible signs of facial and neck skin aging were treated with fractional, nonablative Q-switched 1,064-nm Nd:YAG laser device (Pixel QS Nd:YAG; Alma Lasers Ltd, Caesarea, Israel). Treated areas were the face, including the periorbital and perioral regions (particularly the upper lip), neck, and chest. Treatments consisted of 3 sessions at 2- to 4-week intervals. Follow-up was performed monthly following the final treatment. The Alexiades-Armenakas Comprehensive Grading Scale of Skin Aging was employed to assess efficacy. Pain ratings were recorded by 10-point visual assessment scoring.

Results: Employing the validated, quantitative grading scale for rhytides of the face and neck, a 0.29 grade improvement, or 11.3% improvement, over baseline grade was observed in the 7-subject cohort that completed follow-up following a mean of approximately 2 treatments at approximately 1-month follow-up. No pain and rapidly resolving minimal erythema were noted in all subjects during treatment.

Conclusion: The results of this pilot case series suggest that the treatment with the fractional, nonablative Q-switched 1,064-nm Nd:YAG laser device significantly improves superficial rhytides. With its outstanding safety, it seems to be particularly suitable for the treatment of sensitive areas, such as the periorbital region, lips, neck, and chest. The Q-switched Nd:YAG laser is a facile, safe, and fast treatment for aesthetic skin rejuvenation.

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INTRODUCTION

Age-dependent modification is at the forefront of dermatological research and cosmetic science.[1,2] Besides topical active ingredients and minimally invasive treatments, eg, botulinum toxin or hyaluronic acid, laser devices have expanded into numerous applications to treat a wide array of skin conditions.[2-4] Lasers direct a high-energy beam of a single wavelength of coherent light into specific tissues, varying in strength and the type of tissue they target.[5,6] Corresponding to its chronological development, two main laser classifications have been established in the past regarding the degree of ablation and recovery.[7] Ablative laser systems, eg, CO_2 and erbium-doped yttrium aluminium garnet (Er:YAG) lasers, were among the first resurfacing devices that were proven successful.[5,6] Although highly effective for rejuvenating photoaged skin, the demand for less ablative treatments became evident because of the high risk of unwanted side effects, eg, scarring, infections, edema, or prolonged erythema, combined with a long recovery period and painful treatment sessions.[4] Based on the concept of selective photothermolysis, presented by Anderson and Parrish in the early 1980s, a second, less invasive treatment modality was developed, promising good results while preserving the epidermis.[6,8] This nonablative technique was based on the principle of absorption of light and the different chromophores in the skin, such as water, melanin, or hemoglobin, resulting in selected damage limited to the target.[4,6,8]

In 2004, fractional photothermolysis was introduced which treats only a fraction of the skin, unlike conventional ablative and nonablative lasers.[9] The prototype fractional, nonablative device, a fractional 1,550-nm Er:YAG laser resulted in a combination of epidermal coagulation for a resurfacing effect and dermal denaturation for deeper remodeling repopulated by fibroblast activity of neocollagenesis.[4,5] A new generation of fractional lasers followed, featuring high-power and fractionated beams for nonablative skin remodeling and rejuvenation.[10] Since microscopic columns of thermally denatured epidermis and dermis are created and intervening zones of normal skin facilitate wound rapid healing, fractional, nonablative treatments have been associated with some perioperative discomfort and a 2- to 3-day recovery period with erythema and mild edema.

A novel fractional, nonablative Q-switched neodymium-doped YAG (Nd:YAG) 1,064-nm laser technology is presented here, which combines the benefit of a nonablative and a fractional laser de-

vice. A controlled dermal wound is produced by this near-infrared wavelength, but without harming the epidermis. All stages of wound healing occur under the biologic protection of an intact epidermis, so that no preoperative or postoperative care is necessary.[11,12] Moreover, the treatment is painless, safe, and promises good results in skin remodeling and rejuvenation.[13]The aim of this pilot study was to evaluate efficacy and safety of this new fractional, nonblative Q-switched 1,064-nm Nd:YAG laser device (Pixel QS Nd:YAG; Alma Lasers Ltd, Caesarea, Israel) in the treatment of skin laxity and fine wrinkles at face and neck.

MATERIALS AND METHODS

Subjects

Seven healthy female subjects, aged between 42 and 70 years (mean ± standard deviation 53.6 ± 10.0 years), with visible signs of facial and neck skin aging, minimum grade 2.0 on the 4.0 grading scale were enrolled (Table 1). Verbal and written informed consent was obtained. The subjects were in good health, and none had skin disease or took medications that would impact the skin. Women who were pregnant, planned a pregnancy, and/or nursed a child were excluded from the trial. Also, individuals with a history of cosmetic treatments, eg, botulinum toxin, hyaluronic acid, lasers, as well as surgical "cosmetic" procedures (eg, face-lift) in the treatment area and females who have started or changed hormone replacement therapy within 3 months from study start could not participate in the trial.

Treatment Procedure

The Pixel QSW module is a U.S. Food and Drug Administration–approved nonablative, fractional, high-power Q-switched 1,064-nm Nd:YAG laser handpiece with a passive refractive optical element that creates a 5 mm x 5 mm matrix with 25 microscopic columns of laser-mediated effects (microcolumns) measuring ~200µm in diameter per microcolumn and high power density per pixel (60-130 J/cm^2) (Table 2). The maximal fluence of 1,200 mJ and a spot size of 5 mm were employed. The repetition rate of the laser was adjusted to 4 Hz. The Pixel QSW module is used with the Harmony^{XL} platform (Alma Lasers Ltd). A series of passes (8-12) were administered to each treatment area measuring approximately 20 cm^2 until the clinical end point of diffuse confluent erythema was attained uniformly throughout and repeated until the entire area (face, neck, or chest) was covered. Treatment of each anatomic region (eg, face, neck, or chest) required approximately 20 minutes per site, totaling 400 J per treatment area for the face (1,600 J for full face) and 3,600 J for chest. Treated areas included the face, including the periorbital and perioral regions (particularly the upper lip), neck, and chest. Treatments consisted of 3 sessions at 2- to 4-week intervals. Follow-up was performed monthly following the final treatment.

"Although the exact mechanism of action is not fully elucidated,[15] it is generally accepted that the noninvasive induction of the dermal wound-healing reaction may be the reason for the rapid responder rate."

FIGURE 1. Before **a,c)** and after **b,d)** treatment with Pixel QS Nd:YAG laser (Alma Lasers Ltd, Caesarea, Israel).

Clinical Evaluation

The Alexiades-Armenakas Comprehensive Grading Scale of Skin Aging[14] was employed to assess efficacy (Table 1). This 4.0-point grading scale has been extensively tested and employed for evaluating laser and energy-based cosmetic treatments. Digital photographs were taken at baseline and at each follow-up interval. Grading was conducted by the investigator at baseline and at each follow-up interval in each category following Pixel QSW treatment in the current study. For safety evaluations, patients were evaluated after treatment. Pain ratings using a 10-point visual assessment scale (VAS; 1 = no pain, 10 = worst pain ever felt) were recorded immediately upon conclusion of the treatment. Patients were instructed to monitor for side effects or complications and to follow up during the posttreatment interval should any adverse events arise. At the follow-up intervals, patients filled out posttreatment questionnaires regarding adverse events and clinical outcome (Figure 1).

RESULTS

Efficacy

Seven female subjects were enrolled in this pilot case series and completed all treatment and follow-up visits. Efficacy was scored on rhytides of the face using the Alexiades-Armenakas grading scale (Table 1).[14] The mean baseline grade in rhytides across the subject population was 2.54 ± 0.45. The mean number of treatments was 2.57 ± 0.49 with a mean follow-up interval to date of 1.29 ± 0.7 months following final treatment. In

TABLE 1.

Quantitative Comprehensive Grading Scale of Rhytides, Laxity, and Photoaging[14]

Categories of Skin Aging and Photodamage

Grading Scale	Descriptive Parameter	Rhytides	Laxity	Elastosis	Dyschromia	Erythema-Telangiectasia (E-T)	Keratoses	Texture
0	**none**	**none**	**none**	**none**	**none**	**none**	**none**	**none**
1	**mild**	wrinkles in motion, few, superficial	localized to nasolabial (nl) folds	early, minimal yellow hue	few (1-3) discrete, small (<5 mm) lentigines	pink E or few T, localized to single site	few	subtle irregularity
1.5	**mild**	wrinkles in motion, multiple, superficial	localized, nl and early melolabial (ml) folds	yellow hue or early, localized periorbital (po) elastotic beads (eb)	several (3-6) discrete, small lentigines	pink E or several T, localized 2 sites	several	mild irregularity in few areas
2	**moderate**	wrinkles at rest, few, localized, superficial	localized, nl/ml folds, early jowls, early submental/ submandibular (sm)	yellow hue, localized po eb	multiple (7-10) small lentigines	red E or multiple T, localized to 2 sites	multiple, small	rough in few, localized sites
2.5	**moderate**	wrinkles at rest, multiple, localized, superficial	localized, prominent nl/ml folds, jowls and sm	yellow hue, po and malar eb	multiple, small and few large lentigines	red E or multiple T, localized to 3 sites	multiple, large	rough in several, localized areas
3	**advanced**	wrinkles at rest, multiple, forehead, periorbital and perioral sites, superficial	prominent nl/ml folds, jowls and sm, early neck strands	yellow hue, eb involving po, malar and other sites	many (10-20) small and large lentigines	violaceous E or many T, multiple sites	many	rough in multiple localized sites
3.5	**advanced**	wrinkles at rest, multiple generalized, superficial; few, deep	deep nl/ml folds, prominent jowls and sm, prominent neck strands	deep yellow hue, extensive eb with little uninvolved skin	Numerous (>20) or multiple large with little uninvolved skin	Violaceous E, numerous T, little uninvolved skin	little uninvolved skin	mostly rough, little uninvolved skin
4	**severe**	wrinkles throughout, numerous extensively distributed, deep	marked nl/ml folds, jowls and sm, neck redundancy and strands	deep yellow hue, eb throughout, comedones	numerous, extensive, no uninvolved skin	deep, violaceous E, numerous T throughout	no uninvolved skin	rough throughout

the 7-subject cohort, mean follow-up grade was 2.25 ± 0.38. The mean grade improvement was 0.29 grades or 11.3% improvement from baseline following an average of 2 treatments at the 1-month follow-up interval (Table 3).

Safety

Subjects rated pain associated with the treatment immediately posttreatment using a 10-point VAS (1 = no pain, 10 = worst pain ever felt). The VAS pain rating was reported as 1 across the 7 trial subjects (Table 3). Immediately after the treatment, mild confluent erythema was observed in all subjects. Erythema dissipated within minutes to 1 hour in all subjects. In 2 subjects, pinpoint petechiae were observed in the infraorbital region when vascular dark circles were present preoperatively. These petechiae resolved within 48 hours. No other adverse events were recorded. There was no incidence of edema, ecchymosis, crusting, vesiculation, or dyspigmentation. No scarring was observed.

TABLE 2.

Technical Specification for Fractional Q-switched Nd:YAG (1,064 nm) Module	
Technology	Nd:YAG Q-switched
Wavelength	1,064 nm
Repetition Rate	1, 2, 4 Hz
Pulse Duration	20 nanoseconds
Spot Size	5 mm x 5 mm (25 dot pattern)
Water	++
Coagulative	+++
Depth	2-3 mm

Nd:YAG, neodymium-doped yttrium aluminum garnet.

TABLE 3.

Demographics, VAS Scores, and Rhytide Grades at Baseline and Posttreatment With Fractional Q-switched Nd:YAG (1,064 nm) Laser						
Subject	**Age, y**	**Rx#**	**Follow-up, mo**	**Baseline**	**Post-treatment**	**VAS Score**
1	70	3	1	3.5	3	1
2	43	3	1	2.25	2	1
3	57	3	3	2.5	2.25	1
4	55	2	1	2.25	2	1
5	60	2	1	2.5	2.25	1
6	42	3	1	2	1.75	1
7	48	2	2	2.75	2.5	1
Mean	53.57	2.57	1.29	2.54	2.25	1
SD	10.01	0.49	0.70	0.45	0.38	0

Nd:YAG, neodymium-doped yttrium aluminum garnet; SD, standard deviation; VAS, visual assessment scale.

DISCUSSION

Scientific research in the field of energy-based and light-based procedures made it possible to develop a very new and innovative generation of lasers that combine the benefit of a nonablative and a fractional laser device promising skin rejuvenation without harming the epidermis.[11-13] With this pilot case series, we performed one of the first systematic reports evaluating efficacy and safety of the fractional, nonablative Q-switched 1,064-nm Nd:YAG laser device (Pixel QS Nd:YAG, Alma Lasers Ltd) in the treatment of rhytides of the face, neck, and chest. Employing the validated, quantitative grading scale for rhytides of the face and neck,[15] a 0.29 grade improvement or 11.3% improvement over baseline grade was observed in the 7-subject cohort that completed follow-up following a mean of approximately 2 treatments at approximately 1-month follow-up. Additional improvement is expected with further follow-up intervals, as has been demonstrated with all prior nonablative treatments.

The preliminary case series presented here demonstrates that the treatment with the novel fractional, nonablative Q-switched 1,064-nm Nd:YAG laser device (Pixel QS Nd:YAG, Alma Lasers Ltd) appears to be effective in the treatment of fine lines and wrinkles of the face, neck, and chest with the significant advantages of being virtually painless and requiring no recovery time. Clinical outcome was observed beginning at 2 weeks following the first treatment and results in a less wrinkled and superiorly textured skin, especially around the eyes and the perioral region. Although the exact mechanism of action is not fully elucidated,[16] it is generally accepted that the noninvasive induction of the dermal wound-healing reaction may be the reason for the rapid responder rate.[17] This technology is based on the heating of the subdermal layer and the underlying extracellular matrix, which is followed by tissue contraction and a tightening of the skin.[4] This controlled thermal injury results in tissue shrinkage followed by an inflammatory response accompanied by the migration of fibroblasts into the area.[18,19] This proliferative phase is therefore characterized by an upregulation of collagen expression (neocollagenesis/remodeling),[16] thereby resulting in contracture and tightening of the injured tissues. This newly deposited extracellular matrix may be used to strengthen the skin.[20]

In years past, the Q-switched Nd:YAG (1,064 nm) was employed for nonablative laser resurfacing[21-23]; however, the current device presents several important technological advances that likely account for the markedly improved efficacy. In the 1990s, the Q-switched Nd:YAG (1,064 nm) was employed in defocused mode at 6-15 J/cm^2 and a 6-mm spot size for the treatment of rhytides, with mild efficacy. These reports suggested improvement in fine wrinkles and skin elasticity.[11,22,24] The focal point of the standard Q-switched Nd:YAG (1,064 nm) had been designed at the skin surface, to target melanin pigment, thereby necessitating its application in defocused mode to avoid crusting and splatter. In contrast, the fractional Q-switched Nd:YAG (1,064 nm) described here has a focal point of 100 u, just beneath the epidermis, with greater penetration in the absence of epidermal crusting. The delivery of this wavelength in fractional mode also results in a far higher peak power of 60-130 J/cm^2 per microscopic treatment zone, which likely explains the augmented efficacy achieved with this technology. Since the wavelength is applied directly to the skin surface instead of in defocused mode, penetration depth of up to 3.5-4 mm is expected, which may also play a role in the augmented efficacy reported here as compared with prior modalities.[25]

In marked contrast to other laser devices,[26-28] results show also that the treatment with the current fractional Q-switched Nd:YAG (1,064 nm) laser is characterized by an outstanding safety, even for areas with high risk of scarring such as the chest. No pain and rapidly resolving minimal erythema were

noted in all subjects during treatment. No recovery time was required. No adverse events were reported.

This is the first clinical report detailing the protocol and initial results regarding safety and efficacy for this novel fractional nonablative technology. Further large-scale clinical trials are indicated to statistically analyze long-time effectiveness.

CONCLUSION

The results of this clinical study suggest that the treatment with the fractional, nonablative Q-switched 1,064-nm Nd:YAG laser device (Pixel QS Nd:YAG; Alma Lasers Ltd) significantly improves superficial rhytides. With its outstanding safety, it seems to be particularly suitable for the treatment of sensitive areas, such as the periorbital region, lips, neck, and chest. The Q-switched Nd:YAG laser is a facile, safe, and fast treatment for aesthetic skin rejuvenation and also the first and only fractional technology that is both virtually painless and without downtime.

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DISCLOSURES

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