APPLICATION OF DIODE PUMPED ND:YAG LASER FOR ALLERGIC RHINITIS

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In Japan, nearly 15 to 20 % of the population suffers from allergic rhinitis during the spring season. Conventional treatment with oral anti-histamines has side-effects such as drowsiness and dryness of the throat and is not acceptable for some patients.

Laser treatment usually uses the carbon dioxide (CO₂) laser to char the mucosal lining of the inferior turbinate in order to prevent onset of symptoms. This treatment has a downtime of roughly one month. Complications such as pain and hemorrhage sometimes require hospital admission. We have been using a flashlamp pumped Nd:YAG laser since 1993 with more favorable results both in efficacy and efficiency of treatment with less patient discomfort. A single treatment session takes around 2 to 3 minutes for both sides compared to 20 to 40 minutes with the CO₂ laser and the downtime, which consists of rhinorrhea, is much shorter lasting only 2,3 days to up to one week. Treatment using the flashlamp pumped Nd:YAG laser is very reliable but improvement may be achieved using a diode laser pumped Nd:YAG laser where theoretically the homogeneity of the incident laser beam will increase. We report our experience using the hardware developed by Fibertech Co. on 40 patients as a preliminary report with further reports with larger series of patients ensuing. We also compare this new laser system with the conventional YAG laser and describe the advantage of the diode laser pumped Nd:YAG laser in the treatment of allergic rhinitis, especially in an office practice setting of ENT doctors.

Introduction

In, Japan nearly 15-20% of the population suffer from cedar pollenosis during the spring season (mid-February to late-April). Symptoms consist of rhinorrhea and congestion of the nasal air passage accompanied by irritation and itch of the eyes. The severity of the symptoms ranges from slight discomfort to inability to conduct normal daily activities. The number of patients is growing year by year and the severity of symptoms is increasing in most patients. The most common treatment of pollinosis at local private ENT clinics is prescription of oral anti-histamines and topical nasal

decongestants with steroids added in severe cases. However medication has its side-effects such as drowsiness and dryness of the throat and is not acceptable in many patients. Recent protocol for medication is commencing ingestion 2 to 3 weeks prior to the anticipated period of onset of symptoms. Oral ingestion must be continued throughout the whole season (2 to 3 months). Even so, the patients must protect themselves with masks and may suffer from symptoms on days with high pollen counts. The medical costs associated with allergic rhinitis may not be high for the individual but the prevalence of allergic rhinitis is such that the burden on the Japanese social medicine cannot be overlooked.

Laser ablation of the mucosal lining of the inferior turbinate using the carbon dioxide (CO₂) laser was introduced in 1982 ⁽¹⁾ and showed promising results ranging from 60 to high as 85% efficacy in prevention

Manuscript received: February 2006

Accepted for publication: February 2006

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Table 1: Specification of Diode laser pumped Nd:YAG laser produced Fiber Tech Co. Japan (**Fig. 1**)

Wave length	1064nm
Output power	0.1-8w
Mode	CW
Silica fiber core diameter	600μm
SMA connector Laser tip	round glass tip Φ2mm
Width	180mm
Hight	460mm
Length	460mm
Total weight	24kg

of onset of nasal symptoms. ^(2,3) However the CO₂ laser ablation has certain drawbacks and at Ohshiro Clinic, we have been using the flash lamp pumped Nd:YAG laser for the treatment of allergic rhinitis since 1993. Recently we have started using a diode laser pumped Nd:YAG laser. This laser system was developed at our request by Fibertech Co. (**Fig. 1**). We show that Nd:YAG laser treatment is superior compared to CO₂ laser treatment and that this newly developed laser system has advantages over the conventional flash lamp pumped laser system while the efficacy and safety is matched for the treatment of allergic rhinitis.

Purpose of study

The purpose of this study was to reconfirm the safety of the diode laser pumped Nd:YAG laser system compared to the conventional flash lamp pumped Nd:YAG laser system. We also sought any idiosyncrasies of this

Table 2: Subjective Assessment of the effects

Extremely effective	>90% clearance of symptoms
Effective	60-90% clearance of symptoms
Moderately effective	30-59% clearance of symptoms
Not effective	0-29% clearance of symptoms
Exacerbation	worsening of symptoms
Efficacy was determined as ER(efficacy rate) = (extremely effec. + effec.) / total patients	

new laser system that might need refinement for use of this laser system. Our goal is to create a laser system which is safe, effective, durable and easily handled by those who are not use to lasers.

Materials and Methods

40 consecutive patients were enrolled in the study for the treatment using the diode laser pumped Nd:YAG laser during April 16, 2005 to May 2, 2005. All patients were treated by well experienced MD's (**Table. 1**). Following initial examination patients were seated in an armchair and were anesthetized with 8% lidocaine solution sprayed into each nostril (**Fig. 2**). Treatment commenced immediately following anesthesia (**Fig. 3**). Treatment parameter was such: 8 w, 0.5second laser irradiation followed by 0.5 second rest, total irradiated energy at 200 joules. Patients returned to the clinic at 2 to 4 weeks after treatment for assessment. Subjective

Fig. 1: The diode laser pumped Nd:YAG laser hardware developed by Fibertech Co. Japan. Maximum output 8w with pulse preset at 0.5 seconds. Note the small size of the hardware just slightly larger than a desk top computer.

Fig. 2: Anesthesia of a patient immediately before treatment. 8% lidocaine solutions is sprayed into the narii of the patient. The patient will feel a stinging sensation upon the application of the anesthesia.

Fig. 3: Actual treatment of a patient. The laser probe is inserted into the narii and laser is emitted evenly to the surface of inferior turbinate surface. No endoscopic guidance is required. The whole procedure takes less than 5 minutes.

assessment from patients was presented in a 5 grade scaling system (**Table. 2**).

Results

Of the 40 patients treated with the diode laser pumped Nd:YAG laser, 26 patients were available for follow up. The efficacy ratio is determined as the sum of extremely effective and effective patients divided by the total number of patients treated. Two patients (7.7%) and 9 patients (34.6%) responded extremely effective and effective respectively for a efficacy rate (ER) of 42.3% whereas 7 patients (26.9%) responded moderately effective and 6 patients (23.1%) responded as not effective. There were no cases in which symptoms were exacerbated and no side-effects requiring medical attention was observed. Two patients (7.7%) stated that they could not determine whether or not laser had any effect even though they felt that the symptoms were alleviated (**Table. 3**). Usual reaction to laser treatment consists of rhinorrhea. We inform all patients that though the severity may differ from patient to patient, rhinorrhea will appear as early as 1 hour following treatment and last as long as 1 week with the most severe rhinorrhea lasting for the first 2 to 3 days. In this present study 19 patients had documentation on the subject. Four patients had no rhinorrhea at all, post-treatment (of which 3 had no effect of treatment). Four, two, one and one patients had increased rhinorrhea for 1, 2, 3 and 5 days respectively. Seven patients had increased rhinorrhea for 1 week (**Table. 4**). No

side effect requiring medical attention was noted. Rhinorrhea lasted on the average of 3.4 days. The presence or lack of rhinorrhea has no implication on treatment outcome. This result does not differ from our previous experience.

Discussion

It is obvious from our result that the safety of the diode laser pumped Nd:YAG laser is compatible with the conventional flash lamp pumped Nd:YAG laser system. Theoretically, there should be no difference between the two, since both laser systems emit the same 1064nm near infra-red laser beam used at nearly the same parameter (8w 0.5sec pulse length, total energy 200 joules for the diode laser pumped laser, and 10 w 0.5sec pulse length, total energy 200 to 250 joules for the flash lamp pumped laser). However, there may be subtle discrepancies between utility of the laser systems which may compromise the safety of the treatment. From our experience, it seemed that the patients experienced less pain during treatment when using the diode laser pumped system compared to the flash lamp pumped system. This can be attributed to the fact that treatment using the diode laser pumped system was performed at 8w which is 20% lower than the conventional treatment method. Previous treatment

Table. 3: Result

Treatment period: April 16, 2005 to May 2, 2005		
Extremely effective	2/26	7.7%
Effective	9/26	34.6%
Moderately effective	7/26	26.9%
Not effective	6/26	23.1%
Exacerbation	0	0 %
Not determined	2/26	7.7%
ER=11/26 42.3%		

Table. 4: Side-effects

No complication arose that required medical attention	
Post-treatment rhinorrhea:	
19 patients had documentation on the subject	
4 patients had no rhinorrhea at all, post-treatment (of which 3 had no effect of treatment).	
4, 2, 1, 1 patients had increased rhinorrhea for 1, 2, 3 and 5 days respectively	
7 patients had increased rhinorrhea for 1 week	
Average period of rhinorrhea = 3.4 days	

parameters were set by past experience alone and no study has been performed on identifying the optimum parameter. This may have affected the ER of the study. In a previous unpublished study on the efficacy of Nd:YAG laser treatment using 10w, the ER of experienced MD's was 67.5%. The 42.3% ER in this study is substantially lower and if the 8w setting alone is responsible for the decrease in ER we must reconsider the parameter of the new laser system. However the design of this study was set to confirm the safety of the laser system and hence the time period of the study (late April to early May) may not have been optimal to identify the best treatment setting. The period of late April to early May is usually the end of the cedar pollinosis season and patients presenting symptoms during this period may suffer symptoms less than what they suffered earlier in the season and may have found difficulties in responding to the actual percentage of resolution attributable to laser treatment. There were 2 patients who could not determine whether it was the laser treatment or spontaneous resolution of symptoms at the end of the cedar pollinosis season. In this study we did not discriminate between seasonal pollinosis and perennial allergic rhinitis and this may have affected the ER of a single treatment since patients with perennial allergic rhinitis usually require repeated treatment for the alleviation of symptoms. This study confirms the safety of this laser system but further study of the ER of the diode laser pumped Nd:YAG laser is required.

The laser treatment of allergic rhinitis first appears in literature using the carbon-dioxide (CO₂) laser in 1982⁽¹⁾. Since then, usage of numerous lasers using various methods have appeared,^(4,5,6,7). The use of the Nd:YAG laser first appears in Medline in 1995 from a report by Ito H. et al.⁽⁸⁾ (however there are reports earlier than this not listed in Medline). At Ohshiro Clinic we have adopted this contact method of Nd:YAG laser irradiation to the inferior turbinate mucosa with success^(9,10,11). Probably the greatest difference between treatments of allergic rhinitis using the CO₂ laser and the Nd:YAG laser is the goal and aim of the treatment. The goal of the CO₂ laser treatment is to either ablate or char the nasal mucosal lining of the inferior turbinate which result in complete destruction of mucosal structure. Following a month long healing process the mucosa is replaced by scar tissue and hence mucosa is unable to react to allergic stimuli. This treatment can be performed in an outpatient basis but must be performed in a surgical setting. Topical surface anesthesia must be performed several times and in some cases the time for anesthesia alone can take up to 20 minutes. Treatment is per-

Table. 5: Problems Associated with CO₂ Laser Treatment for Pollinosis

Treatment period	•must be performed well before onset of symptoms
Treatment time	•20 to 30minutes time for each naris
Pain	•high despite local anesthetics
Sequela	•post-operative hemorrhage, sometimes requiring hospitalization •pain •rhinorrhea and complete nasal obstruction lasting for 2 weeks. Downtime lasts for 1 month

formed under the guide of an endoscope and takes 15 to 20 minutes per turbinate. Although nasal packing is not necessary, there is the risk of post-operative hemorrhage sometimes requiring hospitalization. The patient must withstand roughly 2 weeks of complete nasal obstruction and rhinorrhea, and another 2 weeks of crust removal and occasional nasal bleeding and tenderness. The patient can be aware of the effect of the treatment only after the one month healing process and if the patient has only seasonal allergic rhinitis, he/she must wait until the pollen season to actually know if the treatment was effective or not. Problems associated with CO₂ laser treatment for pollinosis are shown in the **Table. 5**. This type of treatment needs to be performed in large hospitals with ENT departments and may be acceptable for the severe rhinitis patients but is hardly possible in a small private practice setting with patients presenting with less severe symptoms.

As for the treatment using Nd:YAG laser, total destruction of the mucosal lining of the inferior turbinate is not the treatment objective. The mucosa remains intact even after treatment and there is no visible change to the mucosa (**Figs. 4 & 5**). Treatment goal is to transfer enough energy to the nasal mucosa to perhaps denature and change the physical properties of the mucosal cell membrane as to diminish any reactivity to the inhaled allergens. Treatment starts with the application of 8% lidocaine anesthesia. The anesthesia is sprayed 2 to 4 times per nostril. The patient will feel a stinging sensation for roughly 30 seconds where upon the anesthesia is completed. Laser irradiation can immediately be performed by slowly progressing the laser probe into the nasal orifice. No pressure is applied while the laser is being emitted, and no endoscope is required for the procedure. Two hundred joules of laser is irradiated to the surface of inferior turbinate which takes only about 50 seconds per turbinate and the whole procedure including anesthe-

Fig. 4-1: Pre-treatment intranasal photograph. Edema of the mucosa surface can be seen along with discharge.

Fig. 4-2: Post treatment intranasal photograph.

Fig. 5-1: Pre-treatment intranasal photograph.

Fig. 5-2: Post-treatment intranasal photograph. Edema of the mucosa is reduced and there is no nasal discharge present. Note there is no visible change to the mucosal surface such as scarring or charring.

sia requires only 2 to 3 minutes (**Table. 6**). The patient may feel occasional pain but this is well tolerable as can be seen in our experience of children as young as 6 years of age. The treatment using the Nd:YAG laser is a quick procedure that does not require a surgical setting with no risk compared to that of the CO₂ laser. The greatest advantage of the Nd:YAG laser treatment is that there is very little post-operative discomfort. While those treated with the CO₂ laser must suffer symptoms for approximately 1 month, those treated with the Nd:YAG laser can resume normal daily activi-

ties immediately and will only suffer from rhinorrhea which itself will last for 1 week with the first 2 to 3 days the most severe. Even then the amount of nasal discharge is much less compared to onset of allergic rhinitis and in many cases the amount of discharge is negligible. Another advantage of the Nd:YAG laser treatment is that it can be performed at any time, even after the onset of symptoms, whereas the CO₂ laser treatment must be performed well before the onset of symptoms, sometimes as early as October or November of the previous year in order to prepare for

Table. 6: Application of Nd:YAG Laser (Benefits Over CO₂ Laser)

Treatment period	•may be performed immediately before or even after onset of symptoms
Treatment time	•2 to 3 minutes for both narii
Pain	•low with usage of local anesthetics
Sequela	•rhinorrhea lasts 2,3days. 1week at most nasal obstruction in low number of cases
Shortness of down-time allows patients to receive multiple treatments	

Table. 7: Comparison of Nd:YAG laser and CO₂ laser treatment for pollinosis

Clinic	Ohshiro clinic	other clinics and institutions
Laser used	Nd:YAG	CO ₂ , Nd:YAG,KTP
Treatment time	5 minutes	20-40 minutes
Nasal function	Retains normal function	Dysfunction due to ablation
Side effects	2,3 days up to 1 week (rhinorrhea , obstruction)	1months (pain, obstruction, rhinorrhea)
Appearance of effect	As early as 2,3 days normally 1 week	After 1 months
Treatment period	Treatment during the pollen season is possible	Must be treated before season

the spring season. The ease and safety of the Nd:YAG laser treatment allows both the surgeon and the patient certain benefits. The surgeon can treat more patients per day without worrying of any post-operative problems and for patients, they can receive repeat treatments if the first treatment does not suffice. Roughly 70% of patients respond favorably after a single treatment. Nearly half of those who did not respond to the first treatment will respond after successive second and third treatments for a cumulative response rate of 84% (**Table. 7**). The disappointment that the patient will feel after a failed attempt with the CO₂ laser is obviously much greater and almost all patients will feel reluctant to receive another CO₂ laser treatment.

Our ER of 67.5% is a modest data because of the strict criteria of efficacy. This data was accumulated in 2002 which was the worst cedar pollinosis season in Japanese history. From experience the amount of pollen in the air directly affects the severity and prevalence of pollinosis and the outcome of treatment. This is why it is difficult to directly compare any parameter of laser treatment unless the comparison takes place simultaneously. We have evidence that the ER in other years match those reported in literature.

Though we have demonstrated the superiority of the Nd:YAG laser treatment over CO₂ laser treatment, the number of institution or private clinics using the Nd:YAG laser is small and there is no sign of increase. Small clinics may continue to use the CO₂ laser while larger institutions may experiment using other devices. The reasons why the Nd:YAG laser is not as popular as the CO₂ laser can be considered as follows. First concerning the hardware, the CO₂ laser was one of the earliest developed lasers. Its utility as in being used as a laser scalpel or for ablation and dessicataion and the

clearly visible tissue-laser interaction makes the laser useful in just about all fields of medicine. The relatively small size of the laser system and low maintenance costs is another reason for its popularity. **Fig. 6** shows the picture of Nd: YAG Laser (Heracles 5040 LASER-SCOPE Co., Ltd). Specification of machine is shown in the **Table. 8**, its deeper penetration depth of the incident laser beam allows for very effective interstitial laser treatments but the lack of visible laser tissue interaction can cause unwanted damage to surrounding tissue and hence treatment using the Nd:YAG laser requires more experience on the part of the attending surgeon. A flash lamp pumped system is much larger than the gas lasers and requirement for an effective cooling system makes the system even larger. The short lifespan of the flash lamp and running costs associated with this makes the Nd:YAG laser a much more expensive system to operate and using such machinery only on limited basis of seasonal pollinosis may not be appealing to private practitioners.

Another reason that laser treatment of allergic rhinitis is not widespread lies in the fact that there is very limited access to lasers both for the ENT doctors and patients. Only limited number of doctors has access to laser treatment and can gain only limited

Table. 8: Specification of Heracles 5040 LASERSCOPE Co., Ltd.

Flashlamp pumped Nd:YAG laser	
Wave length	1064nm
Max. Output	40w
Silica fiber core diameter	600μm
Sapphire tipped hand piece is used	

Fig. 6: The conventional flash lamp pumped Nd:YAG laser system used at Ohshiro Clinic. Heracles 5040 LASERSCOPE Co. Ltd. The size of the system is about that of a small desk or bookshelf.

Fig. 7-1: The compact size of the diode laser pumped Nd:YAG laser (left side) compared to a Q switched Ruby laser system (right side).

Fig. 7-2: A large laser system is impractical for an office based practice. Such lasers are only welcome at laser centers.

experience. Since the number of doctors performing the procedure is limited to large institutions which have access to lasers, mainly the CO₂ laser, the number of patients receiving treatment is small. Most doctors opening new private practices will probably not incorporate laser treatment at all and those few who do will rather endorse the CO₂ laser from their sparse experience for reasons mentioned above rather than gamble with a new device, even though the Nd:YAG laser has more therapeutic benefits for patients.

At Ohshiro clinic, we were well aware of the disadvantages of the flash lamp pumped Nd:YAG laser hardware. The media attention that we have received for the Nd:YAG laser treatment of allergic rhinitis has led to a gross increase in patient volume. This motivated us to develop a new Nd:YAG laser system that would clear all of the above mentioned problems. At our request, Fibertech Co. developed a diode laser pumped Nd:YAG laser used in this study. The greatest difference of the newly developed hardware compared to the conventional laser hardware is its size. The size of the laser system is just slightly larger than a desk top computer (**Fig. 7**). Just the compact size of the laser system solves most of the problems associated with incorporating a Nd:YAG laser in the treatment armament of a private office practice. By using a diode laser pumping system, the total size of the system can be decreased and also the diode laser pumping system does not require a large cooling system which can decrease the size even more. The energy efficiency of the laser diode allows the laser to operate with the normal 100 V electrical supply found in normal house-

hold and office settings so there is no need for additional electric construction. The difference of the lifespan of the laser diode compared to the flash lamp directly affects the running cost and maintenance fee. Concerning the hardware, we believe that this laser system has solved all the problems that a private practitioner would encounter (**Table. 9**). However there still remains the problem of treatment parameter for the less experienced surgeon. Conventional flash lamp pumped Nd:YAG laser allowed the output as high as 40w with pulse setting anywhere from 0.1 second to continuous emission. This type of laser is very useful for experienced laser surgeons who may use the laser in many settings for variety of treatments. However for the less experienced laser surgeon or an ENT doctor who will use the laser for only limited treatments, in this case the treatment of allergic rhinitis, the wide selection of the laser parameter will only be confusing. We requested that the software of the new diode laser pumped Nd:YAG laser system be fixed to 2 to 4 treatment parameter most suitable for the treatment of allergic rhinitis. This will allow the ENT doctor to press a single button for the selection of the treatment parameter and to treat a patient safely without worrying of unexpected treatment sequela. Further refinements are probably necessary before this hardware becomes commercially available.

Conclusion

We have shown that the Nd:YAG laser is much safer, less time consuming and can be applied with minimal

Table. 9: The Advantages of the Diode Laser Pumped System(LD) over Flash Lamp Pumped Systems

	Flash lamp	LD	Note
Energy efficiency	2.5%-3%	20%-30%	Approximately 10 times more efficient
Cooling device	Water cooled (partially air cooled)	Completely air cooled	Higher cooling efficiency allows for smaller sized system
longevity	2000~5000 hrs.	20000~50000hrs.	Approximately 10 times longer

patient discomfort compared to the CO₂ laser. The newly developed diode laser pumped Nd:YAG laser can be used safely and effectively with less patient discomfort. Although further studies on the optimum

parameter for the treatment of allergic rhinitis need to be conducted, we hope that this new diode laser pumped Nd:YAG laser will encourage more ENT doctors to treat allergic rhinitis using lasers.

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