Long Term Follow-up of Intralesional Laser Photocoagulation (ILP) for Hemangioma Patients

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Background and Objectives: Hemangiomas remain a challenge for patients and plastic surgeons. Promising results have been reported using intralesional photocoagulation (ILP) for treatment. The objective of our study is to review the long term results of a large series of hemangiomas in patients treated by ILP.

Materials (Subjects) and Methods: A retrospective review of 684 hemangiomas in patients were treated by ILP with an Nd:YAG (neodymium-yttrium-aluminium-garnet) (1064 nm) laser over a period of 10 years (January 1996 – January 2005). Patients’ ages ranged from one month to 11 years 5 months (mean, 1 year 10 months). The patient group consisted of 474 females and 210 males.

Results: Patients were treated with an Nd:YAG laser delivered through a 600 m optical fiber. Laser power was set at 7 to 15 watts (W) and delivered with pulse duration of 7 to 15 seconds (s). The results showed 603 (88.6%) patients had more than 50% reduction of the volume in hemangiomas at 3 months after one treatment; and 663 (96.9%) patients had more than 50% reduction of the volume at 3 months after two treatments. Patients who had continuous ILP achieved excellent results.

Conclusions: Postoperative complications have been related to photocoagulation that has been delivered too extensively or superficially, with resultant ulceration, infection, bleeding, and scarring. These complications can be avoided if this potential for harm is kept in mind.

Key words: intralesional photocoagulation, ILP, Hemangioma, Nd:YAG Laser, Vascular malformation

INTRODUCTION

In our long-term study, ILP is observed to be an effective treatment modality for hemangiomas including those that are clinically diagnosed as being problematic. Vascular anomalies have an extremely colorful history, rife with misconceptions and confusing terminology.

At infancy, hemangiomas are a common birthmark that present a challenge to medical physicians. Traditional management of hemangiomas has been based on the assumption that this birthmark will involute spontaneously by the age of 3 to 7 years. 1-6 Symptomatic problems such as ulceration, infection, bleeding, obstruction of orifices, or psychological factors may indicate the necessity of treatment. A number of alternative methods such as carbon dioxide snow, liquid nitrogen, and radiation therapy have been applied for treatment of hemangiomas, resulting in even more complications.

Treatment ranging from steroid therapy, to Interferon-alpha2a, to compression therapy has been administered as an alternative treatment of hemangiomas. Surgical intervention was limited primarily to the patients in whom physiological functions were impaired and/or only if there was severe bleeding or ulceration that did not respond to conservative thera-

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Patients who may benefit from laser treatment are those with symptomatic hemangiomas such as ulceration, obstruction, or bleeding. Hemangiomas that evolve rapidly often respond favorably to laser treatment. It may arrest growth and even induce involution. In general, hemangiomas may be treated with either the pulsed dye laser (PDL) or argon laser. Several authors have shown PDL to be effective in eliminating the superficial component of hemangiomas. This effect can be improved by using high-fluence PDL in conjunction with cryogen spray cooling (CSC). However, the laser is used superficially and therefore is limited in its ability to influence the deep component of the hemangioma.

A Nd:YAG laser is a contact treatment for hemangiomas, but its success is limited due to the incidence of scarring. The coagulative properties of the Nd:YAG laser, used in conjunction with CSC, has been reported by Chang, et al. who used a non-contact procedure for the photocoagulation of hemangiomas. Although epidermal protection and deep-tissue photocoagulation can be achieved, the capability of light from the Nd:YAG laser to penetrate to depths of 5-7 mm is still limited. Thus, treatment of any lesion larger than this would be met with substantial margins.

The argon laser was the first laser used for vascular malformations. It was used primarily for port wine stains (PWS) but was occasionally used for hemangiomas in infancy. For treating superficial lesions, the argon laser is effective because the lesion can quickly be flattened and the problem eliminated. However, the argon laser is also limited in sophisticated use, as scarring often results and limitations in attaining requisite lesion depth arise.

Large, symptomatic hemangiomas or those located on the face cause significant functional impairment and cosmetic deformity, and thus, require direct intervention. Lesions throughout the head and neck area frequently affect important neurovascular structures. In these cases, the percutaneous injection of sclerosants may be applicable. Caution should be exercised when using sclerosants because they can induce ischemia or cavernous sinus thrombosis.

The approach to patients with hemangiomas begins with an adequate knowledge of their history. Magnetic resonance imaging (MRI), magnetic resonance angiography (MRA) or ultrasonography are needed for preoperative evaluation of the involved areas and preparation. The anatomically sensitive areas of the involved areas were protected. General anesthesia using an endotracheal tube was favored for the majority of patients. The surgical areas were prepared with Betadine solution. Local anesthesia (1% Xylocaine with 1:100,000 adrenaline) was infiltrated at the site of needle insertion to minimize bleeding.

MATERIALS AND METHODS

Patients
A retrospective review of 684 hemangiomas in patients treated by ILP with an Nd:YAG laser was over a period of 10 years (January 1996 – January 2005). This represents the largest series treated by a single plastic surgeon (C-J C) reported to date. Patients’ ages ranged from one month to 11 years 5 months, with the average age being 1 year 10 months. There were 474 females and 210 males, 680 of the patients Asian, and 4 Caucasian.

Preoperative management
The approach to patients with hemangiomas begins with an adequate knowledge of their history. Magnetic resonance imaging (MRI), magnetic resonance angiography (MRA) or ultrasonography are needed for preoperative evaluation of the involved areas and preparation. The anatomically sensitive areas of the involved areas were protected. General anesthesia using an endotracheal tube was favored for the majority of patients. The surgical areas were prepared with Betadine solution. Local anesthesia (1% Xylocaine with 1:100,000 adrenaline) was infiltrated at the site of needle insertion to minimize bleeding.
Procedures

An 18-gauge Angiocath® (Deseret Medical, Inc., Sardy, Utah) was inserted through the mucosa at the mouth angle or the safe zone adjacent to the lesions to facilitate the introduction of the laser fiber. A Nd:YAG laser delivered with a 600 µm optical fiber was used in either continuous mode or pulsed mode. We recommended the pulse mode rather than continuous mode because the delivery of energy is more controlled and predictable. The Nd:YAG laser was set at 7 to 15 W with a pulse duration suggested at 7 to 15 s. In one of our previous studies using a bovine liver model, we showed that a single 10 s, 10 W pulse of intralesional Nd:YAG laser energy produces a sphere of tissue damage measuring 1 cm in diameter. We therefore recommended for this study that the tip of the fiber be kept 1 cm from the skin surface to prevent skin burns. Repeated pulses to the same region were not recommended so as to avoid excessive thermal effect that could be induced by the laser. This complication is preventable if a lattice is used to mark the treated areas (Figure 1). Laser energy was delivered individually to each partition of the lattice. Visible shrinkage and firmness of the hemangioma signaled the end-point of treatment. Careful administration and observation of temperature and texture, in regards to shrinkage and/or firmness, was conducted to determine the safest, yet most operative, duration of treatment.

For minimizing the incidence of complications, prevention of the thermal effect induced by laser is important. Continuous monitoring of the superficial temperature using a Digital Infrared Scanner (Microscanner™ D1001, EXERGEN Corporation, Newton, MA, USA) is useful for this purpose. Also during ILP, irrigation with cold water on the surface of the lesion is necessary. The use of a cold compress on the treated areas post-operatively was recommended to decrease thermal effects and minimize complications effectively. Following the removal of the fiber and Angiocath®, pressure was applied to the hemangioma(s) and the entry site(s) were closed if necessary with a simple suture. As a result of the ILP treatment, total energy delivered was calculated and recorded as the product of the power (W), pulse duration (s), and number of pulses.

Postoperative management

Based on the severity of the hemangiomas, patients were discharged on the same day or admitted to the hospital for observation. A cold compress was suggested for 48 hours post-operatively followed by warm compresses for another 48 hours. These postoperative interventions were helpful for preventing early complications such as superficial thermal injuries, alteration of pigmentation (hyperpigmentation and/or hypopigmentation). In our study, patients that experienced massive hemangiomas at face and oropharyngeal area were in the infant group and remained nasotracheally intubated during the early postoperative period for airway patency, which was observed to be the result of the swelling and compression of their more fragile and narrower airways. Any entry wounds and/or ulcerations were treated with topical antibiotic-epinephrine ointment. Antibiotic administration was only indicated for those hemangioma patients with ulceration and/or infection, after receiving ILP treatment. In such cases, a single dose of intravenous cephalosporin was used intraoperatively and a subsequent 3-day course of oral cephalosporin postoperatively. For patients with massive hemangiomas a further application of acetaminophen for analgesic purposes was used postoperatively as well. All patients were closely observed at 1 week, 3 weeks, 6 weeks, and then monthly and yearly to determine the response, complications and long term results.

RESULTS

Among the 684 patients, 483 (70.6%) hemangiomas were located on the head and neck, 48 (7.0%) on the trunk, 75 (11.0%) on the upper extremities, 69 (10.1%) on the lower extremities, and 9 (1.3%) in the perineal area. The area of the hemangiomas ranged from 2x2 cm² to 30x35 cm² with a mean area of 64 cm². The problems with hemangiomas seen at the time of consultation were as follows: obstruction 327 (47.8%), rapid proliferation 178 (29.0%), pain 90 (13.2%), deformity 87 (12.7%), ulceration 42 (6.1%), bleeding 30 (4.4%), and infection 18 (2.7%). Postoperatively, one specimen was taken from a patient with a hemangioma located on the face for biopsy observation and analysis to obtain histological findings (Figure 2).

The follow-up period ranged from 1 year 6 months to 12 years 3 months (mean 2 years 9 months). Early complications following ILP included superficial skin burns 75 (11.0%), infection 45 (6.60%), minimal scarring 30 (4.40%), ulceration 15 (2.20%), bleeding 12 (1.80%), and/or nerve injuries 9 (1.30%) (Table 1). In these early complications skin burns, infection, scarring, ulceration, and bleeding were managed so that a smooth recovery was achieved. Six of the nine patients with nerve injuries experienced transient facial palsy, two patients had ulnar nerve palsy, and one patient...
Fig. 1: The treated area is marked with a lattice. Laser energy is delivered to each partition via an 18-gauge Angiocath® for ILP.

Fig. 2: The histopathological findings of the damage zone in the hemangioma immediately after ILP demonstrates vaporization, carbonization, thrombogenesis, and coagulation.

Fig. 3A: A three-month-old baby girl suffers from a proliferating hemangioma on her right peri-orbit, causing obstruction to her right eye.

Fig. 3B: Preoperative MRI of patient in Fig. 3A demonstrates a hemangioma involving the right orbital area.

Fig. 3C: Significant improvement is visible in Fig. 3A patient at age 4 after one ILP and reconstructive surgery.

Fig. 3D: Postoperative image of Fig. 3A patient following ILP at the age of 11.

Fig. 4A: A two-month-old baby girl suffers from a proliferating hemangioma on her face, causing obstruction to her right eye.

Fig. 4B: Recovery is evident in Fig. 4A patient at the age of 12 after ILP.
had median nerve palsy. After a conservative treatment, these complications resolved themselves over a period of 6 months. One case involved a rapidly proliferating hemangioma on the head and neck and received intralesional photocoagulation at a total energy delivery of 40,000 jules (J). Resulting complications of anemia and hyperkalemia in this patient were believed to have been due to the extensive tissue destruction that occurred, however such complications were corrected under intensive care. Once the hemangiomas became involutive, texture changes with redundant skin were noted in 30 patients (4.40%). These patients received reconstructive procedures as well as laser dermabrasion for improvement.

The primary efficacy measure was a quantitative assessment of the reduction in the volume of the hemangiomas. The results were rated using the following scales: 1, poor (0-25%); 2, fair (26-50%); 3, good (51-75%); and 4, excellent (76-100%). Excellent results were seen in 561 patients (82.0%) who underwent one treatment (Figure 3A-D), 54 patients (7.9%) required two (Figure 4A-D), and 18 patients (2.6%) received three or more treatments to achieve excellent recordings. A summary of the results show 603 (88.6%) patients had more than 50% reduction of the volume at 3 months after one treatment; 663 (96.9%) patients had more than 50% reduction of the volume at 3 months after two treatments. One particular case involved the laser reconstruction on a patient to treat a hemangioma upon a cleft lip. Patient’s age was one month and received ILP treatment to reduce hemangioma volume. This allowed for patient to receive further reconstruction of the cleft lip following successful ILP treatment at three months of age. The statistical analysis was performed by Robert L. Newcomb, Ph.D., who is the Director of the Center for statistical consulting at the University of California, Irvine. Based on the Irvine-Fisher test, the final outcome between the patients who required one and two treatments demonstrated no statistical significant differences when compared to the three, four and five treatment patients (Chi-square = 0.606; p = 0.739). Patients who had continuous ILP achieved excellent results (Table 2). These results indicate that the severity of the involved area was not directly related to the final outcome, but to the number of treatments; some patients needed more treatment to

### Table 1. Complications of 684 Hemangioma Patients After ILP

<table>
<thead>
<tr>
<th>Type</th>
<th>Early [3 months]</th>
<th>Late [6 months]</th>
<th>Final [&gt;6 months]</th>
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<tr>
<td></td>
<td>No. of Patient(s) (%)</td>
<td>No. of Patient(s) (%)</td>
<td>No. of Patient(s) (%)</td>
</tr>
<tr>
<td>Skin burn</td>
<td>75 (11.0)</td>
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<td>0 (0)</td>
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<tr>
<td>Infection</td>
<td>45 (6.6)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Scarring</td>
<td>30 (4.4)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Ulceration</td>
<td>15 (2.2)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Bleeding</td>
<td>12 (1.8)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Nerve injury</td>
<td>9 (1.3)</td>
<td>3 (0.44)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Anemia and hyperkalemia</td>
<td>1 (0.15)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Texture change</td>
<td>30 (4.4)</td>
<td>30 (4.4)</td>
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</table>

### Table 2. Treatment and Reduction Rate of 684 Hemangioma Patients After ILP

<table>
<thead>
<tr>
<th>No of Treatment(s)</th>
<th>Poor (0%-25%)</th>
<th>Fair (26%-50%)</th>
<th>Good (51%-75%)</th>
<th>Excellent (76%-100%)</th>
<th>Total</th>
<th>Percentage</th>
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<td>1</td>
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<td>42</td>
<td>561</td>
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<tr>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>54</td>
<td>8.3</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>9</td>
<td>12</td>
<td>1.8</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>6</td>
<td>0.9</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Chi-square = 0.606; p = 0.739
sustain excellent results. Following initial treatment of all patients, ILP-treated area was closely observed and changes that occurred were recorded to determine whether patients were to undergo further treatment. Successive treatment was administered after three months if there were no visible signs of ill-reaction to ILP. Furthermore if initial symptoms did not improve postoperatively, successive treatment could be administered sooner. Our study supports equivalent outcomes regardless of the number of treatments required.

**DISCUSSION**

The Nd:YAG laser has been recommended for its versatility in the treatment of capillary hemangiomas. This laser emits a continuous light in the near-infrared range (1064 nm) and can penetrate into the skin at depths of up to 5-7 mm to produce a thermal coagulation necrosis — the degree of which may be controlled by varying the power and time of exposure. ILP using the Nd:YAG or KTP (potassium-titanium-phosphate (532 nm)) wavelength with the bare fiber or fiberoptic can be inserted directly into the hemangiomas, as seen in our previous studies with the KTP laser system. A comparison of the two wavelengths (Nd:YAG and KTP lasers) used showed that ulceration occurred in 6% of the Nd:YAG laser group and 43% of the KTP laser group. The wattage delivered in the Nd:YAG group was 7, versus 10 to 16 in the KTP group. Both were lower in wattage than previous reports citing 35 W. These results suggested that the lower energy of the Nd:YAG laser was preferred, for the goal of applying such treatment was to coagulate the vasculature as opposed to vaporize it. For this study the histological findings at the damage zone, demonstrated in Figure 2, may support the possible mechanisms of such thermal effects, thrombogenesis, and/or the initiation of involution in hemangiomas.

While ILP results are very encouraging, potential risks when treating vascular anomalies are possible. In our series specifically, an overwhelming majority of the patients benefited a reduction of their hemangiomas and saw an increase in functional improvement. We considered the end-point of our treatment to be the point where a decrease in the vascularity of the hemangioma was achieved. For rapidly proliferating hemangiomas, especially those located in critical areas, intralesional steroids (Kenalog 40, Celestone, 2 to 3 mg/kg) were injected with intralesional photoagulation for PDL treated areas, however concerning the patients that were used in this study undergoing ILP, no steroid injection/application was administered. This allowed for safe reconstructive procedures. In the hemangiomas that were not resectable, the endpoint of treatment was achieved by minimizing the impact on the functional and cosmetic concerns of the patient.

One case concerning a 3-month-old baby girl with an extensive and rapidly proliferating hemangioma on the head and neck received intralesional photoagulation. We treated the whole involved area simultaneously (total energy delivered was 40,000 J). Subsequently, she developed severe anemia and hyperkalemia. These problems were corrected and observed under intensive care and were resolved after using intravenous hydration, antibiotics, sodium bicarbonate, and blood transfusion. We believe that the complications of anemia and hyperkalemia in this patient were due to the extensive tissue destruction that occurred.

It is also important to note that complications may arise due to individual operator techniques and the specialized equipment required for the appropriate system needed. Disregard of these aspects could result in an injury to the vital structures surrounding the therapeutic zone. Additionally, the tip of the fiber may break off during treatment. As it is hard to control the therapeutic zone, the possibility of skin burn, thermal injury to the vital organs, perforation of major vessels, and breaking off of the fiber may result.

One previous study that included 12 patients with voluminous hemangiomas on the head and neck were treated with a KTP laser to deliver intralesional photoagulation at 15 J. For the purpose of supporting this long-term research, our 3-month postoperative analysis of those 12 patients produced results that demonstrated that 92% of patients had a reduction of more than 50% in the size of their hemangiomas. Eight percent of this patient group (12 patients) had more than 50% reduction in the size of the hemangiomas observed after a follow-up period of 6 months postoperatively. Following our initial report, 23 patients with periorbital hemangiomas were treated (KTP, n=7; Nd:YAG, n=16) at two medical centers: the University of California Irvine Medical Center in the US and Chang Gung Memorial Hospital in Taiwan, respectively. A KTP laser was used at 10 to 16 W along with an Nd:YAG laser used at 7 W. All but two patients had a greater than 50% reduction in the size of their hemangiomas. One of these was considered a treatment failure because the patient had only 10% reduction after 3 months. 61% of the patients had seen a 50% or more reduction in their hemangiomas during 3 to 8 months and 83% of the patients had 50% or greater reduction of their hemangiomas within 8
months. No other long-term side effects or complications were noted. Functional levels (i.e., vision, preoperative ulceration, obstruction of nasal passages, auditory canal obstruction, and cosmetic appearance) improved dramatically during the follow-up periods.

The resultative advantages of our study beyond that of ensuring a safe and effective means of treatment consisted of: providing an adjustable energy load, minimal invasion, less bleeding, minimal wound and wound care, short operative time, and short hospital admission period. Patients who were treated for excessive hemangiomas were consulted and given a full physical evaluation prior to ILP treatment in order to ensure the patients’ safety and proper diagnosis for optimal ILP application. It is important to note that of these patients, 88.6% of the patients in our study observed a significant reduction of up to 50% of initial complications associated with the patients' hemangiomas observed and recorded at their consultation after only one treatment. Patients were given the option of receiving repeated ILP which, based on our experience, could be combined with other forms of treatment without the need for increased hospital admission for the patient(s). The most impressive advantages of ILP are that it is minimally invasive and that the area exposed during treatment is smaller. In our histopathological findings, ILP is executed via a combination of vaporization, photocoagulation and thrombogenesis. Clinically, ILP is not limited to the application of the proliferating phase of hemangiomas for it can be used in each phase of hemangiomas. Based on observations during postoperative follow-up care, rebound growth was not observed in our study. Nonetheless, if the involution of the treated hemangiomas is ever incomplete, ILP can be safely repeated post-treatment within a period after 3 to 6 months and in 3-month intervals by use of laser treatment. For hemangiomas in infancy, once the proliferation can be controlled, patients were arranged a monthly follow-up in the first year. For the rapidly proliferative or extensive hemangiomas, the proliferation was and can be controlled effectively.

For minimizing the incidence of complications, prevention of the thermal effect induced by laser is crucial. Continuous monitoring of the superficial temperature using an infrared thermospectrometer is useful for this purpose. Also during ILP, irrigation with cold water on the surface of the lesion is necessary. The use of a cold compress on the treated areas postoperatively is strongly recommended to decrease thermal effects and minimize complications effectively. However a practical cooling system, used in conjunction with the laser during intralesional photocoagulation, is an important area that warrants further study.

**CONCLUSION**

Throughout the course of our long term study, ILP using an Nd:YAG laser is an effective treatment modality for hemangiomas. For complicated cases ILP can be administered for treating hemangiomas immediately and for those that impede on patients’ critical areas. Possible areas of focus for further study are: differing wavelengths other than those applied to an Nd:YAG laser, improving use of laser devices to perhaps advanced semiconductor systems with a more adequate guide for delivering the energy into a very anatomically sensitive area, and a practical cooling system for use in conjunction with the laser device during treatment.

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