Distribution of Intra- and Extraocular Pain Induced by Argon Laser Photocoagulation

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TAMAI, M. and MIzuno, K. Distribution of Intra- and Extraocular Pain Induced by Argon Laser Photocoagulation. Tohoku J. exp. Med., 1984, 142 (4), 427-435 — We examined the characteristics of ocular pain induced by green argon laser photocoagulation in 13 eyes of ten patients. The patients had retinal detachment or proliferative diabetic retinopathy treated surgically by a 360 degree buckling procedure or vitrectomy with an encircling band on the equator before the laser treatment. All patients complained of ocular pain in various degrees during coagulation on and anterior to the buckle. We confirmed that this kind of ocular pain was asymmetrically distributed; it was dense in the superotemporal quadrant, sparse in the inferonasal quadrant, and intermediate in the remaining two. Seven patients (eight eyes) complained not only of ocular pain, but also of extraocular pain in the ipsilateral upper lid, forehead, and parietal and temporal areas of the head. Both kinds of pain diminished by retrobulbar anesthesia, or by the time interval following surgery.

Photocoagulation, utilizing either xenon arc, argon, or other laser energy, is a new modality of insult to the eye that has been applied to the treatment of various ocular diseases. Patients periodically experience ocular pain during this procedure. Such pain is evident when the peripheral retina and choroid are coagulated, for example, in panretinal photocoagulation for patients with diabetic retinopathy. Ocular pain induced by photocoagulation was reported around the 12, 3, 6, and 9 o'clock areas of the retina (L'Esperance 1975).

In the present study, we examined ocular pain elicited by argon laser photocoagulation therapeutically delivered to eyes treated with equatorially placed encircling bands for rhegmatogenous detachment and for those that underwent vitrectomy and encircling procedures for proliferative diabetic retinopathy or trauma. Patients complained of severe pain in and around the eyeball following coagulation. Ocular pain was much more severe in the superotemporal quadrant than in the other three quadrants. There were also complaints of
extraocular pain extending to the ipsilateral upper lid, forehead, and parietal and temporal areas of the head. Both kinds of pain were found to be time-dependent after the operation.

**Materials and Methods**

The Mizuno binocular indirect argon laser photocoagulation delivery system (Nidec, Tokyo) (Mizuno 1981; Mizuno and Takaku 1983) was used, with the following parameters: 300 μm spot size, 350 mW of power, and 0.1 second duration. Photocoagulation was delivered at and between each vertical and horizontal meridian and on and around the equatorial buckle for a total of three to five spots at each of the eight locations. Opacity of the cornea or media and/or edema of the retina sometimes made it difficult to coagulate with the selected settings. In these cases, photocoagulation was either postponed until the view became clear or settings were adjusted to get the same coagulating spots. To eliminate the possibility of ocular pain by accidental iris burn, the slit lamp delivery system of this machine was used to photocoagulate on the buckle in the left eye of a 62-year-old man who had traumatic aniridia and vitreous hemorrhage.

Ocular pain elicited by photocoagulation was classified into the following grades: Grade 5; severe pain, unable to continue photocoagulation; Grade 4; severe pain, possible to continue photocoagulation; Grade 3; moderate pain; Grade 2; minimum pain; Grade 1; no pain, but photic sensation.

The ocular status of the 13 eyes studied is given in Table 1. Patients ranged from 35 to 65 years in age. Photocoagulation was principally applied for or during ten days to two weeks after ophthalmic surgery. All patients answered the following three questions of our classification table: (1) What grade was the pain? (2) How was the pain distributed in the globe? Score 5 indicates the most painful and 1 the least painful regions. (3) Were the ocular pains referred or expanded to another region? The extraocular pain in question No. 3, called “referred pain”, was classified into four grades of increasing severity from non to #.

To evaluate the severity of ocular pain induced by photocoagulation in relation to the time period after surgery, we used three patients who underwent two photocoagulation sessions. These patients were: a 62-year-old man after vitrectomy and an encircling procedure whose left eye was coagulated 5 1/2 and 23 weeks after surgery; a 44-year-old woman after vitrectomy and an encircling procedure in her left eye for proliferative diabetic retinopathy; and a 35-year-old man who had an encircling procedure in his right eye for aphakic rhegmatogenous retinal detachment. The last two cases had photocoagulation at 2 and 12 weeks after surgery.

The diminishment of pain created by the excitation of sensory nerves innervating the intra- and epibulbar tissues with photocoagulation was examined with retrobulbar anesthesia with 2% lidocaine. Also, the contribution of excitation of cutaneous sensory nerves to

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referred pain was evaluated after local anesthetics of 2% lidocaine were subcutaneously injected at the most painful area, and patients were asked whether their referred pain was diminished or not.

**RESULTS**

*Relationship of coagulating conditions and induced ocular pain*

In all cases, the severity of ocular pain increased proportionately with the intensified power of the argon laser and the expanded size of the spot. For example, the phakic left eye of a 52-year-old woman who underwent an equatorial encircling operation for rhegmatogenous retinal detachment was photocoagulated on the ninth (Fig. 1A) and tenth days (Fig. 1B) after surgery. The severity of her ocular pain increased from Grade 3 to 5 with increased power from 350 to 500 mW and enlarged spot size from 300 to 600 μm.

![Fig. 1. Left phakic eye of a 52-year-old woman who had an equatorial encircling procedure for rhegmatogenous retinal detachment. Photocoagulation was performed at 350 mW of power, and 300 μm spot size for 0.1 sec duration in A and 500 mW, 600 μm, and 0.1 sec in B. The severity of ocular pain was graded 3 and 5, respectively. Referred pain was not designated. Small open circles and numbers around each figure of the fundus in these and all following ones indicate locations of coagulation spots and intraocular distribution of the pain; 5 indicates the most severe pain; 1, the least; and 4, 3 and 2 intermediate grades according to severity.](image)

*Relationship of coagulated region and induced ocular pain*

The most painful site was the superotemporal peripheral area, that is, between 9 and 12 o’clock in the right eye and 12 and 3 o’clock in the left eye (Fig. 2A). These relationships were exemplified in the aphakic left eye of a 44-year-old woman with proliferative diabetic retinopathy who underwent photocoagulation two weeks after an equatorial encircling procedure. The parameters for photocoagulation were 350 mW of power, 300 μm spot size, for 0.1 second. Coagulation to the posterior region of the buckle at the vascular arcade elicited no pain, or Grade 1 (Fig. 2B). When this patient received coagulation on and anterior to the
Fig. 2. Left aphakic eye of a 44-year-old woman who had vitrectomy and equatorial encircling procedure for proliferative diabetic retinopathy. Coagulating conditions were 510 mW of power, 300 µm spot size, and 0.2 sec duration posterior to the equator in A and 500 mW, 300 µm, and 0.1 sec between the equator and the ora in B. The severity of ocular pain was graded 1 and 3, respectively. Referred pain was not designated. The most painful regions are shown by filled circles in C. If the patient indicated his most severe pain (Grade 5) at both the 9 and 12 o'clock positions, two filled circles were drawn. Therefore, the number of filled circles is more than the number of eyes. Both left and right examined eyes are shown.

buckle, she experienced Grade 3 ocular pain (Fig. 2C). In almost all patients, very slight or no pain was noted when the area posterior to the equator was coagulated; the pain sharply decreased when the coagulating site was moved from the upper temporal area. Patients also designated Grade 1 for coagulation at the inferonasal area.

Relationship of ocular pain and postoperative periods

It had been our experience that patients who have equatorial encircling procedures at a fairly long period before photocoagulation have relatively slight ocular pain. The 65-year-old man who had the first photocoagulation in his right eye 5 1/2 weeks after surgery complained of severe ocular pain (Grade 5) and severe referred pain (Grade #) to the frontal and parietal regions (Fig. 3A). Five months and three weeks later, additional photocoagulation was applied. At that time, he reported an induced pain of Grade 2 and no referred pain. The intraocular distribution of pain was nearly the same as before (Fig. 3B). When the 44-
A 431-year-old woman had the first photocoagulation two weeks after surgery she complained of Grade 5 ocular pain and Grade * referred pain. At her second session 12 weeks after surgery, her ocular pain was Grade 3 and referred pain was Grade non. She reported that the character of ocular pain was completely different from the previous one. The 35-year-old man also had the first photocoagulation session two weeks after surgery. He complained of Grade 4 ocular pain and Grade * referred pain. At the second coagulation, delivered 12 weeks after surgery, his ocular pain decreased to Grade 2 and referred pain to Grade non. The intraocular distribution of pain was nearly the same. These findings are shown in Fig. 3C.

Characteristics of extraocular pain induced by photocoagulation

When eight of 13 eyes in seven patients were coagulated, patients reported not only intraocular pain, but also extraocular pain distributed in the ipsilateral upper lid, forehead, and temporal and parietal areas. Occasionally, the patients
described the pain as being so severe that they felt as if every hair was electrified, and they were hypersensitive to all kinds of stimulation, even a small puff of air. Apparently, these pains did not extend to the opposite side of the midline or beyond the ipsilateral canthal line (Fig. 4A and B). Five patients reported especially painful regions in two areas; the superior orbital margin (Fig. 4A) and just temporal to the lateral canthus (Fig. 4B). The relationship of these eight eyes to the grade of intraocular pain is shown in Fig. 4C.

**Intra- and extraocular pain induced by photocoagulation and anesthetics**

Both of these pains were for the most part eliminated by retrobulbar anesthesia (Fig. 5A to C). One patient was administered analgesics composed of 0.15 g of isopropylantipyrine, 0.06 g of aryl-isopropyl-acetyl-urea, 0.25 g of phenacetin and 0.05 g of caffeine one hour before photocoagulation; however, her intraocular pain was Grade 5 and the referred pain was Grade # (Fig. 5B). To determine whether the referred pain was actually induced by the stimulation of a peripheral sensory nerve, local anesthetics were subcutaneously injected around the painful

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**Fig. 4.** Region of extraocular referred pain induced by photocoagulation is shown by shaded areas in A and B. Filled circles show especially painful points designated by five of seven patients. C shows the relationship of intra- and extraocular pain in Grade and number of eyes. Eyes with both kinds of pain are indicated by filled squares. Intraocular pain was solely elicited by photocoagulation in one of three eyes in Grade 5, one of six eyes in Grade 4, and three of four eyes in Grade 3.
Ocular Pain by Photocoagulation

Fig. 5. Intra- and extraocular pain and anesthetics. Right aphakic eye of a 45-year-old woman who had vitrectomy and encircling procedure for proliferative diabetic retinopathy. Photocoagulation elicited Grade 5 intraocular pain and + referred pain (A). Pain was not diminished by administration of oral analgesics (B). Intraocular pain was reduced to Grade 3 and referred pain to non by retrobulbar anesthesia (C). Local anesthetic was injected at the most painful point on the superior orbital margin of the right aphakic eye of a 26-year-old man who had an equatorial encircling procedure for rhegmatogenous retinal detachment (E). His intraocular and referred pain were not diminished and remained in same (Grade 4; +) before (D) and after (F) injection.

point on the superior orbital margin (Fig. 5E), but the referred pain was not decreased (Fig. 5F). The referred pain seemed to be slightly relieved by the administration of oral analgesics after photocoagulation.
DISCUSSION

It is well known that patients with ophthalmic problems can suffer severe pain not only after corneal surgery, various intraocular and epibulbar diseases and as a result of high intraocular pressure, but also after intra- and extraocular surgery. Ocular sensations, including cornea-related ones, are transmitted by the long ciliary nerve to the nasociliary nerve, which merges with the ophthalmic nerve, the first branch of the trigeminal nerve (Duke-Elder 1961). Castro-Correia (1967) reported dense distribution of sensory nerves to the uveal tract. These sensory nerves are divided into three groups, lateral, intermediate, and medial choroidal nerve plexuses. The finest are located just below the retinal pigment epithelium.

Today xenon arc and argon laser photocoagulation techniques are widely used in ophthalmology, and it is well known that the procedure elicits ocular pain. We also recognize that patients some time complain of ocular pain when photocoagulation is applied to the peripheral retina. Until now, the details of ocular pain have not been reported, probably due to problems in methodology. Classification of pain is difficult because of large interindividual differences in terms of threshold and/or sensitivity to a specific stimulation. Levels of intraindividual pain can be altered by a patient's mental and physical condition. We cannot tell how meaningful the classifications are in our present report, because we separated Grades 4 and 5 by the ability to continue photocoagulation. However, our present experiments made clear the following four characteristics of ocular pain elicited by argon laser photocoagulation. (1) Intraocular pain elicited by argon laser photocoagulation was asymmetrically distributed; dense in the peripheral and upper temporal retina and choroid and sparsely in the posterior and inferonasal quadrant. (2) In some cases, argon laser photocoagulation elicited not only intraocular pain but also pain to the ipsilateral upper lid, forehead, and parietal and temporal areas of the head. The lower lid and lower temple and occipital regions were not affected. (3) Both kinds of pain, whether induced or referred, were decreased as the time after surgery lengthened. (4) Both intra- and extracocular pain were diminished by analgesics and were greatly decreased by retrobulbar anesthesia.

The direct effect of the laser beam on the retinal pigment epithelium and choroid was histologically examined in humans (Little 1973). We observed that painful points were densely distributed in the peripheral upper temporal area, but no pain was felt adjacent to this area. This suggests that nerves, nerve endings, or similarly responding nervous elements must be stimulated by photocoagulation.

Our findings suggest that two kinds of pain are elicited by direct stimulation of the nervous tissues with the energy of the argon laser beam, and that their distribution is denser in the peripheral upper temporal retina and choroid. These kinds of pain could not be caused by direct coagulation to the iris because (1)
severe direct and referred pains were elicited even in a case of traumatic aniridia, (2) no coagulation burns were found in the pupillary border by slit lamp examination, and (3) the pain was felt even through the slit lamp delivery system of the coagulation beam.

At present, we have very little information concerning the peripheral and central mechanisms of ocular pain. Three modalities of intraocular sensory nerves are reported; (1) the first branch of the trigeminal nerve, which extends to the cornea and the anterior part of the choroid; (2) pressure-sensitive nerve endings extending to the angle; and (3) proprioceptive nerves extending from the trigeminal nerve to the ciliary muscles (Duck-Elder, 1961). In the present experiments, mainly the first branch of the trigeminal nerve was stimulated by the argon laser. But no anatomical report discusses an asymmetrical distribution of sensory nerves. Our results have suggested this and must be morphologically confirmed.

Referred pain expanding to extraocular areas was also difficult to explain. These painful areas approximately coincide with those innervated by the supraorbital, supratrochlear, and lacrimal nerves, which belong to the ophthalmic nerve, the first branch of the trigeminal nerve (Glacer 1976). These nerves merge with the nasociliary nerve at the superior orbital fissure and combine with the ophthalmic nerve. If huge synchronous afferent impulses were elicited intraocularly and conducted along the nasociliary nerve, those nerves located nearby would possibly be activated. At the sensory center, then, it would appear as if these nerves were stimulated at the innervated areas. These mechanisms are well-known as a possible explanation of referred pain in visceral sensation (Mountcastle 1980). But these mechanisms must be proved in detail with further experimentation.

References