·Clinical Research·

Comparison of laser iridotomy using short duration 532-nm Nd: YAG laser (PASCAL) *vs* conventional laser in dark irides

Hye Jin Chung[1], Hae-Young Park[2], Su-Young Kim[2]

[1]HanGil Eye Hospital, Incheon 403-010, Korea
[2]Department of Ophthalmology and Visual Science, College of Medicine, the Catholic University of Korea, Seoul 137-701, Korea

Correspondence to: Su-Young Kim. Department of Ophthalmology and Visual Science, College of Medicine, the Catholic University of Korea, Uijeongbu St. Mary's Hospital, #271 Cheonbo-ro, Uijeong bu-si, Gyeonggi-do 480-717, Korea. cassiopeia-su@hanmail.net

Received: 2013-11-03 Accepted: 2015-01-24

Abstract

• AIM: To evaluate the outcome of laser iridotomy using 532-nm Nd: YAG laser (PASCAL) with short pulse duration and Nd: YAG laser compared to conventional combined laser iridotomy.

• METHODS: Retrospective, nonrandomized, comparative case series. Forty-five eyes of 34 patients underwent laser iridotomy. Twenty-two eyes underwent iridotomy using short duration PASCAL and Nd: YAG laser, and 23 eyes underwent iridotomy using conventional combined laser method. The average settings of PASCAL were 60 μm and 700-900 mW with a short duration of 0.01s to reduce the total applied energy. The conventional laser was 50 μm and 700-900 mW for 0.1s. After photocoagulation with these laser, the Nd: YAG laser was added in each group. Endothelial cell counts of pre-iridotomy and 2mo after iridotomy were measured and compared.

• RESULTS: All eyes completed iridotomy successfully. The total energy used in the PASCAL group was 1.85±1.17 J. Compared to conventional laser 13.25±1.67 J, the energy used was very small due to the short exposure time of PASCAL. Endothelial cell counts were reduced by 0.88% in the PASCAL group and 6.72% in the conventional laser group (P=0.044). The change in corneal endothelial cell counts before and after iridotomy was significant in conventional combined laser iridotomy group (P=0.004).

• CONCLUSION: Combined PASCAL and Nd:YAG laser iridotomy is an effective and safe technique in the dark brown irides of Asians. Furthermore, the short duration of exposure in PASCAL offers the advantages of reducing the total energy used and minimizing the corneal damage.

• **KEYWORDS:** endothelium; laser iridotomy; 532-nm Nd: YAG laser

DOI:10.3980/j.issn.2222-3959.2015.02.13

Chung HJ, Park HY, Kim SY. Comparison of laser iridotomy using short duration 532-nm Nd: YAG laser (PASCAL) *vs* conventional laser in dark irides. *Int J Ophthalmol* 2015;8(2):288-291

INTRODUCTION

Laser iridotomy became clinically practical after the advent of argon laser technology in the 1970s. By the end of the decade, laser iridotomy had replaced incisional iridectomy as the surgical procedure of choice for angle closure glaucoma. During the 1980s, the YAG laser was introduced, and YAG laser iridotomy was an effective treatment for light-colored irides. But, for Africans and Asians, who have thick, heavily pigmented, dark irides, YAG laser was less effective and argon laser iridotomy required more energy and was difficult to achieve [1-5]. As more energy was needed, more complications arose, such as corneal endothelial loss [6-8]. Therefore, for dark irides, sequential argon laser and Nd:YAG laser iridotomy was invented. Because this combined laser iridotomy reduces the energy used and the laser-associated bleeding, it has been widely used. A semiautomated, fully integrated, slit lamp-based pattern scanning retinal photocoagulator (Optimedica Corp., Santa Clara, CA, USA), PASCAL, has recently been introduced into clinical use [9,10]. It uses frequency-doubled neodymium-doped yttrium aluminum garnet (Nd:YAG) solid-state laser with a wavelength of 532 nm. Most argon lasers have now been replaced by frequency-doubled Nd: YAG or diode lasers due to technical advantages. In this study, we sought to compare the two-laser combined iridotomy using PASCAL and Nd:YAG laser to a conventional combined-laser method. Conventional

Table 1 Demographic characteristics and laser settings $\bar{x} \pm s$

Parameters	PASCAL-Nd:YAG combined laser (n=22)	Conventional combined laser (n=23)	P
Age (a)	67±8 (52-82)	65±7 (50-79)	0.302
Anterior chamber depth (mm)	2.05±0.16	2.08±0.19	0.546
First laser power (mW)	775±58 (725-900)	705±63 (600-800)	[a]0.001
First laser shots (No.)	228±125 (94-650)	188±27 (160-260)	0.129
Laser exposure duration (s)	0.01	0.1	
Nd:YAG laser power (mW)	1.4±0.1 (1.4-1.6)	1.5±0.2 (1.4-1.8)	0.145
Nd:YAG laser shots (n)	6±3 (3-15)	8±3 (6- 16)	0.236
Total energy (J)	1.85±1.17 (0.73-4.90)	13.25±1.67 (10.02-15.60)	[a]<0.001
Reduction rate of endothelial cell counts (%)	0.88±9.45 (-26.52-17.91)	6.72±9.41 (-12.11-31.12)	[a]0.044

Independent t-test; [a]P<0.05.

combined laser method was that after laser photocoagulation which setting was 50 μm, 700-1000 mW, 0.1s, laser photo-destruction added. Present study chose the short duration of PASCAL laser exposure, 0.01s. We compared the total energy needed to penetrate the iris and evaluated the short-term change of endothelial cell counts after laser iriditomy.

SUBJECTS AND METHODS

Subjects This study adhered to the tenets of the Declaration of Helsinki and was approved by the Institutional Review Board of Uijeongbu St. Mary's Hospital, College of Medicine, the Catholic University of Korea, Seoul, Korea. Informed consent was obtained from all patients after receipt of a detailed description of the study. Forty five eyes (34 patients) with primary angle-closure (PAC) were reviewed. Patients visited our clinic between December 2006 and February 2012. Each patient underwent complete ophthalmic examination including gonioscopy. We defined PAC as status in association with a closed angle (presence of >180° angle in which the posterior trabecular meshwork was not visible on nonindentation gonioscopy) without peripheral anterior synechiae. Before laser iridotomy, endothelial cell count was measured by Robo SP 8800 specular microscope (Konan Medical, Torrance, CA, USA). The average cell area values were used to estimate the endothelial cell density (dot method).

Methods Pilocarpine drops (2%) were administered for miosis before laser iridotomy. After one drop of 0.5% proparacaine was administered, an Abraham contact lens (Ocular Instruments, Bellvue, Washington, DC, USA) was placed and possible iris crypt was selected. Our preference was between 11 and 1 o'clock where the opening would be entirely covered by the lid. PASCAL was applied and the average settings for this laser were 60 μm and 700-900 mW with a short duration of 0.01s to reduce the total applied energy. When the posterior pigment layer of the iris was seen or a small bore was acquired, Nd:YAG pulsed laser was applied. As the conventional laser, we had used 532 nm green-light Diode Pumped Solid State laser (Novus spectra; Lumenis Ltd., Santa Clara, CA, USA) for iridotomy. The average settings of this conventional laser were 50 μm and 700-900 mW for 0.1s. After photocoagulation with that laser, the Nd:YAG laser was added. The power of the Nd:YAG laser iridotomy was 1.5 mJ, and 3-15 shots were applied to enlarge the hole and sharpen the margin. After laser treatment, all patients were treated with 0.1% fluorometholone acetate four times a day until reviewed in clinic 1wk later. Two months after laser iridotomy, the corneal endothelial cell count was rechecked.

Statistical Analysis Post-procedure endothelial cell counts were compared with the pre-procedure count using the paired t-test. The laser settings, total energy used and the reduction rate of endothelial cell between the two groups was compared using the independent t-test.All statistical analyses were conducted using SPSS 10.0. (SPSS Inc., Somers, New York, USA); statistical significance was defined as a P<0.05.

RESULTS

We present 45 eyes of 34 patients with dark irides who underwent the combined PASCAL-YAG laser technique or the combined conventional laser technique (Table 1). The PASCAL group included 22 eyes and the conventional laser group included 23 eyes. In all cases, a patent laser iridotomy was created. Between the two groups, there were no significant differences in mean age. The mean PASCAL power was larger than the power of conventional laser (P= 0.001), but the mean number of laser shots was not significantly different. The power and shot numbers of Nd: YAG laser were not significantly different between two groups (P>0.05). In the PASCAL group, the exposure duration of laser was a tenth of that in conventional laser group. Therefore the total mean±standard deviation energy used in the PASCAL group was 1.85±1.17 J, and was much smaller than that used in the conventional laser group (13.25±1.67 J, P<0.001). The reduction rate of endothelial

Table 2 Comparison of endothelial cell counts $\bar{x} \pm s$

Groups	Endothelial cell counts		*P*
	Pre-iridotomy	2mo later iridotomy	
PASCAL-Nd: YAG combined laser	2600±336	2562±290	0.457
Conventional combined laser	2696±326	2506±346	[a]0.004

Paired *t*-test; [a]*P*<0.05.

cell count between two groups was significantly different (0.88% in the PASCAL group, 6.72% in the conventional laser group) (P=0.044). Corneal endothelial cell count was significantly reduced 2mo after laser iridotomy in conventional laser group (P=0.004, Table 2).

Minor iris hemorrhage was identified in one eye of the PASCAL group and was stopped by light pressure with the Abraham contact lens. In the conventional laser group, no iris hemorrhage was found. At 1wk after laser treatment, no inflammation was clinically observed, and a satisfactory iridotomy with a diameter of 200 μm was achieved with a single treatment in all cases.

DISCUSSION

The argon laser has thermal energy and it cauterizes and vaporizes iris tissue, creating a progressively deeper iris defect. This heat not only creates an iris opening but also coagulates adjacent iris blood vessels, preventing bleeding. However, it is exacting to penetrate a thick dark brown iris because of superficial iris char that shields the underlying stroma and pigment epithelium. Thermal energy can also produce complications including permanent corneal burns and focal opacities [11]. One way to minimize these complications and achieve a patent iridotomy in a dark brown iris is to use multiple short duration burns, called the "chipping technique". The important feature of this modification is the short exposure time of 0.02s to 0.05s, with standard settings of 50 μm and 700 to 1500 mW. With this approach, minute fragments of stroma are chipped away, often requiring 200 to 300 applications to penetrate stroma. However, it is also difficult to destroy the thick radial muscle fiber of iris using only this thermal energy. Sequential argon laser and Nd:YAG laser iridotomy was therefore invented. Nd:YAG laser produces an explosion, and the ensuing shock wave has a mechanical cutting effect on iris tissue. However, iris stromal blood vessels are vulnerable to disruption. Using only Nd:YAG laser, there is frequently bleeding from the iridotomy site. Previous argon laser treatment can create a coagulative effect on the stromal vessels and prevent bleeding. Therefore, argon and Nd:YAG laser combined iridotomy has the advantages of both lasers.

Recently, there was an increase in the number of cases of severe irreversible corneal edema after laser iridotomy in Japan [12-14]. Endothelial cell damage or loss probably arises from a combination of factors. These include direct focal injury to the endothelium by the laser, heat dissipated from the iris, thermal damage from a rise in the temperature of the aqueous humor, the mechanical shock waves and turbulent flow in the anterior chamber aqueous during the destruction of the iris, anterior chamber inflammation, iris pigment dispersion, preexisting corneal guttate and a transient rise in intraocular pressure [15-17]. Many centers in Japan have performed pure argon laser iridotomies. Because the pure argon laser iridotomy requires more energy to penetrate the iris than the combined sequential argon and Nd:YAG laser, this large dissipated thermal energy is one of the suspected causes of irreversible corneal edema.

For retinal photocoagulation, the PASCAL laser requires shorter pulse duration (10- or 20-ms compared to 100- or 500-ms in the conventional systems). Shorter pulse duration may be associated with less pain because of decreased thermal diffusion into the choroid, which is rich in sensory nerves. A shorter pulse duration may also lessen the spread of laser burns, resulting in less collateral retinal damage and better preservation of retinal sensitivity [18-20]. We borrowed this concept and added the advantage that short duration reduced the total energy used and minimized the corneal damages. Reducing the total energy and dissipated thermal energy decreases the endothelial cell damages. So, referring to the previously mentioned chipping technique, we used a tenth of the typical duration, 0.01s. We then calculated the energy needed to complete iridotomy and evaluated endothelial cell loss. All results were compared to previous conventional combined laser outcomes. The present method reduced total energy to a seventh part. Corneal endothelial count was not statistically reduced after laser iridotomy in the PASCAL group. But, the change of corneal endothelial cell counts before and after iridotomy was significant in conventional combined laser iridotomy group. The loss rate of endothelium was 0.88% with the PASCAL group, while the conventional combined laser group had a loss rate of 6.72% (P<0.05).

Combined PASCAL and Nd:YAG laser iridotomy is an effective and safe technique in the dark brown irides of Asian. In particular, short duration of exposure in PASCAL offers the advantages of reducing the total laser energy used and minimizing the corneal damage.

ACKNOWLEDGEMENTS

Conflicts of Interest: Chung HJ, None; **Park HY,** None; **Kim SY,** None.

REFERENCES

1 Sun X, Liang YB, Wang NL, Fan SJ, Sun LP, Li SZ, Liu WR. Laser peripheral iridotomy with and without iridoplasty for primary angle-closure glaucoma: 1-year results of a randomized pilot study. *Am J Ophthalmol* 2010;150(1):68-73

2 de Silva DJ, Day AC, Bunce C, Gazzard G, Foster PJ. Randomised trial of sequential pretreatment for Nd:YAG laser iridotomy in dark irides. *Br J Ophthalmol* 2012;96(2):263-266

3 Rao A, Rao HL, Kumar AU, Babu JG, Madhulata U, Arthi J, Tukaram M, Senthil S, Garudadri CS. Outcomes of laser peripheral iridotomy in angle closure disease. *Semin Ophthalmol* 2013;28(1):4-8

4 Peng PH, Nguyen H, Lin HS, Nguyen N, Lin S. Long-term outcomes of laser iridotomy in Vietnamese patients with primary angle closure. *Br J Ophthalmol* 2011;95(9):1207-1211

5 Ramani KK, Mani B, George RJ, Lingam V. Follow-up of primary angle closure suspects after laser peripheral iridotomy using ultrasound biomicroscopy and A-scan biometry for a period of 2 years. *J Glaucoma* 2009;18(7):521-527

6 Park HY, Lee NY, Park CK, Kim MS. Long-term changes in endothelial cell counts after early phacoemulsification versus laser peripheral iridotomy using sequential argon:YAG laser technique in acute primary angle closure. *Graefes Arch Clin Exp Ophthalmol* 2012;250(11):1673-1680

7 Hirayama M, Yamaguchi T, Satake Y, Shimazaki J. Surgical outcome of Descemet's stripping automated endothelial keratoplasty for bullous keratopathy secondary to argon laser iridotomy. *Graefes Arch Clin Exp Ophthalmol* 2012; 250(7):1043-1050

8. Kumar RS, Baskaran M, Friedman DS, Xu Y, Wong HT, Lavanya R, Chew PT, Foster PJ, Aung T. Effect of prophylactic laser iridotomy on corneal endothelial cell density over 3 years in primary angle closure suspects. *Br J Ophthalmol* 2013;97(3):258-261

9 Paulus YM, Jain A, Nomoto H, Sramek C, Gariano RF, Andersen D, Schuele G, Leung LS, Leng T, Palanker D. Selective retinal therapy with microsecond exposures using a continuous line scanning laser. *Retina* 2011;31(2):380-388

10 Muqit MM, Marcellino GR, Henson DB, Young LB, Patton N, Charles SJ, Turner GS, Stanga PE. Optos-guided pattern scan laser (Pascal)-targeted retinal photocoagulation in proliferative diabetic retinopathy. *Acta Ophthalmol* 2013;91(3):251-258

11 Wilhelmus KR. Corneal edema following argon laser iridotomy. *Ophthalmic Surg* 1992;23(8):533-537

12 Shimazaki J, Uchino Y, Tsubota K. Late irreversible corneal oedema after laser iridotomy. *Br J Ophthalmol* 2009;93(1):125-126

13 Ang LP, Higashihara H, Sotozono C, Shanmuganathan VA, Dua H, Tan DT, Kinoshita S. Argon laser iridotomy-induced bullous keratopathy a growing problem in Japan. *Br J Ophthalmol* 2007;91(12):1613-1615

14 Narayanaswamy A, Kumar RS, Aung T, Foster PJ. Argon laser iridotomy-induced bullous keratopathy. *Br J Ophthalmol* 2009;93(6):842-843

15 Lim LS, Ho CL, Ang LP, Aung T, Tan DT. Inferior corneal decompensation following laser peripheral iridotomy in the superior iris. *Am J Ophthalmol* 2006;142(1):166-168

16 Yamamoto Y, Uno T, Joko T, Shiraishi A, Ohashi Y. Effect of anterior chamber depth on shear stress exerted on corneal endothelial cells by altered aqueous flow after laser iridotomy. *Invest Ophthalmol Vis Sci* 2010; 51(4):1956-1964

17 Yamamoto Y, Uno T, Shisida K, Xue L, Shiraishi A, Zheng X, Ohashi Y. Demonstration of aqueous streaming through a laser iridotomy window against the corneal endothelium. *Arch Ophthalmol* 2006;124(3):387-393

18 Nagpal M, Marlecha S, Nagpal K. Comparison of laser photocoagulation for diabetic retinopathy using 532-nm standard laser *vs* multispot pattern scan laser. *Retina* 2010;30(3):452-458

19 Chappelow AV, Tan K, Waheed NK, Kaiser PK. Panretinal photocoagulation for proliferative diabetic retinopathy: pattern scan laser versus argon laser. *Am J Ophthalmol* 2012;153(1):137-142

20 Muraly P, Limbad P, Srinivasan K, Ramasamy K. Single session of Pascal versus multiple sessions of conventional laser for panretinal photocoagulation in proliferative diabetic retinopathy: a comparitive study. *Retina* 2011;31(7):1359-1365