

LASIK AND ARCUATE INCISIONS FOR THE TREATMENT OF POST-PENETRATING KERATOPLASTY ANISOMETROPIA AND/OR ASTIGMATISM

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SUMMARY

Purpose: To study the efficacy of *Laser In Situ Keratomileusis* (LASIK) and *Arcuate Keratotomy* (AK) for the treatment of anisometropia and/or astigmatism after *Penetrating Keratoplasty* (PKP) in an attempt to optimize binocular vision.

Material and Methods: Correction of post-PKP anisometropia and/or astigmatism was considered only when stable refraction was achieved for at least 6 months. Four eyes were treated for anisometropia and astigmatism using the LASIK technique (INPRO Gauss Excimer Laser and SKBM Microkeratome). Five eyes were treated with AK to correct post-PKP astigmatism only. The results were evaluated using the following parameters: uncorrected visual acuity (UCVA), best subjective spectacle correction (BSCVA), corneal uniformity (CU) index and predictive corneal (PC) acuity from the Holladay Diagnostic Summary (HDS) analysis.

Results: Post-PKP anisometropia and astigmatism were treated successfully after primary LASIK in three out of the four cases. One eye needed an additional *diode thermal keratoplasty* (DTK).

Astigmatism post-PKP was treated successfully after primary AK in four of the five cases. One eye needed an additional LASIK.

Conclusion: AK can be used successfully in cases of low-grade post-PKP astigmatism. LASIK gives better results in cases of post-PKP anisometropia and astigmatism. In order to refine the final results a combination with other refractive techniques such as DTK can be proposed. CU index and PC acuity (EyeSys-HDS analysis) are poor predictive parameters for visual outcome in cases of irregular corneal surfaces as it is often the case after PKP.

RÉSUMÉ

But: Etude de l'efficacité du *Laser In Situ Keratomileusis* (LASIK) et de la *kératotomie arciforme* (KA) pour le traitement de l'anisométrie et/ou de l'astigmatisme secondaire à une *kératoplastie transfixiante* (KT) dans le but d'optimiser la vision binoculaire.

Matériel et Méthodes: La correction réfractive de l'anisométrie et/ou de l'astigmatisme après KT n'a été envisagée que 6 mois après obtention d'une réfraction stable. Quatre yeux ont été traités pour anisométrie et astigmatisme par la technique du LASIK (INPRO Gauss Excimer Laser et microkératome SKBM). Cinq yeux ont été traités par la technique de la KA afin de réduire un astigmatisme simple suite à une KT. Dans l'évaluation des résultats, on considère les paramètres suivants: acuité visuelle non corrigée, meilleure correction subjective, index d'uniformité cornéenne (CU index) et acuité visuelle cornéenne prédictive (PC) des tables diagnostiques de Holladay.

Résultats: L'anisométrie combinée à l'astigmatisme après KT ont été traités avec succès par LASIK dans trois des quatre cas considérés. Un cas a nécessité un traitement complémentaire par *kératoplastie thermique au diode*.

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L'astigmatisme simple après KT a été traité avec succès par KA dans quatre des cinq cas considérés. Un œil a nécessité un traitement complémentaire par LASIK.

Conclusion: La KA peut être utile dans la correction de l'astigmatisme simple après KT. Le LASIK par contre est efficace dans le traitement de l'anisométrie combiné à un astigmatisme après KT. Dans le but d'affiner les résultats d'autres techniques réfractives peuvent être ajoutées. L'index d'uniformité cornéenne et l'acuité visuelle cornéenne prédictive des tables diagnostiques de Holladay sont des paramètres peu valables pour l'évaluation de l'acuité visuelle avant et après correction d'anisométrie et/ou l'astigmatisme secondaire à une KT.

SAMENVATTING

Doel: Het evalueren van de doeltreffendheid van *Laser In Situ Keratomileusis* (LASIK) en *Arciforme Keratotomie* (AK) voor de behandeling van anisometropie en/of astigmatisme na *Penetrerende Keratoplastie* (PKP) met als doel het binoculair zicht te herstellen.

Materiaal: De refractieve correctie na penetrerende keratoplastie werd pas uitgevoerd ten minste 6 maanden nadat een stabiele refractie werd bekomen. Vier ogen ondergingen een LASIK behandeling (INPRO Gauss excimer laser en SKBM microkeratoom) voor de correctie van anisometropie en astigmatisme. Vijf ogen ondergingen een AK voor de behandeling van astigmatisme. Volgende parameters werden geëvalueerd: on gecorrigeerde visus, beste bril-gecorrigeerde visus, corneal uniformity en predicted corneal acuity van de Holladay Diagnostic Summary analyse.

Resultaten: Anisometropie en astigmatisme na penetrerende keratoplastie werd in drie van de vier gevallen met succes gecorrigeerd na LASIK. Eén oog onderging een bijkomende *thermische keratoplastie* met de diode laser.

Astigmatisme na penetrerende keratoplastie werd in vier van de vijf gevallen met succes gecorrigeerd na AK. Eén oog onderging een bijkomende behandeling met LASIK.

Conclusie: AK kan nuttig zijn in gevallen waar enkel astigmatisme gecorrigeerd dient te worden na penetrerende keratoplastie. LASIK daarentegen heeft het voordeel om zowel astigmatisme als anisometropie te kunnen corrigeren na penetrerende keratoplastie. In sommige gevallen kan het aangewezen zijn om verschillende refractieve technieken te combineren. CU index en PC acuity zijn parameters met weinig predictieve waarde zowel voor als na correctie van anisometropie en/of astigmatisme na PKP.

KEY WORDS

Penetrating keratoplasty, astigmatism, LASIK, arcuate keratotomy

MOTS-CLÉS

Kératoplastie transfixiante, astigmatisme, LASIK, kératotomie arciforme

INTRODUCTION

Penetrating keratoplasty (PKP) is successfully used for the treatment of corneal disorders such as keratoconus, traumatic scars, congenital dystrophies and scars after viral or bacterial infections. However, astigmatism after PKP is a major complication, which can be corrected by spectacles or contact lenses in most but not all cases. Astigmatism of 3.5 D or higher is more difficult to correct by spectacles (aniseikonia) or by contact lenses (problems of tolerance or stability).

Different techniques have been proposed to treat high post-PKP astigmatism. Wedge resection (21), suture management and *arcuate keratotomy* (AK) (10, 14, 16, 19, 20) do reduce astigmatism to a certain extent but the results are unpredictable. With the advent of the Excimer lasers, this technology was proposed to correct both post-PKP astigmatism and ametropia (1-4, 7-9, 11, 13, 17, 18, 24, 25). *Photo Refractive Keratectomy* (PRK) was first described by Campos (4) for the reduction of astigmatism after PKP. PRK is currently no longer performed on eyes with a corneal graft because of high incidence of haze and regression with loss of best-corrected visual acuity (BCVA). As a result *Laser In Situ Keratomileusis* (LASIK) was proposed by Arenas (3, 4) as an alternative for the treatment of astigmatism and anisometropia after PKP, reducing dramatically the postoperative corneal haze and regression. Disadvantages of this technique are potential corneal weakening or dehiscence of the wound since high external vacuum pressure is applied on an obligatory stitch-free cornea.

The aim of our study was to evaluate the effect of LASIK and AK on post-PKP anisometropia and/or astigmatism.

MATERIALS AND METHODS

In this retrospective study, eight patients (9 eyes) out of 120 patients who underwent PKP between January 2000 and June 2002 needed further correction of post-PKP anisometropia and/or astigmatism. Five eyes (4 patients) were treated by AK; four eyes (4 patients) were treated by LASIK. The indication for surgery was an astigmatism of 3.5 D or more, a subjective visual impairment due to anisometropia and intolerance to optical correction (spectacles or contact lenses). All cases were evaluated after removal of the sutures and presenting a stable refraction during the last 6 months. The pre- and postoperative evaluation included:

- Uncorrected (UCVA) and best spectacle-corrected visual acuity (BSCVA) measured with Snellen optotypes at maximal contrast in decimal notation.
- Optimal subjective refraction.
- Keratometry (KM) measured with the EyeSys, a placido ring-based video-keratography. Corneal uniformity index (CU index) and predicted corneal acuity (PC acuity) were recorded from the Holladay Diagnostic Summary (HDS) maps. Because the EyeSys refers to Snellen acuity only, UCVA and BSCVA were also recorded in Snellen acuity only.
- Corneal pachymetry measured at 1630 Hz (Ophtasonic Pachymeter) was performed in all cases, either to define the depth of the corneal incisions or to decide about the feasibility for LASIK.

AK PROCEDURE

A Liebermann eyelid speculum was inserted in the operated eye. The arcuate incision was performed with a Thornton diamond knife at 90° of the pachymetric depth measured by means of ultrasonography. The incision was made at an optical zone diameter of 5-6 mm on the steepest zone, as indicated by corneal topography.

LASIK PROCEDURE

The INPRO Excimer Laser (Model 200i) and the SKBM microkeratome were used to per-

form LASIK. The correction of astigmatism was done first, followed by the correction of the spherical ametropia. The ablation technique consisted in the treatment of the flattest axis. Two laser spots of 3.5 mm were applied eccentrically on this axis leaving an untreated central zone of 3 mm. The laser settings aimed at the full cylinder correction +10 %. The spherical ametropia was performed on the 6.5 mm central zone.

Tetracaine hydrochloride 0.5 % drops were used for topical anaesthesia. A Liebermann eyelid speculum was inserted in the operated eye. A suction ring (8.5 or 9.5 mm) was then placed on the eye and vacuum suction was activated. The microkeratome was inserted onto the suction ring with the intention to obtain a 160 µm flap. The flap was lifted with an irrigating cannula. The stromal bed was dried with a cellulose sponge. The excimer laser treatment was then applied to the stromal bed using the laser settings as described above.

Patients were allowed to return home after slit lamp examination of the cornea to exclude any early postoperative flap complications.

Postoperatively, patients were instructed to apply Trafloxal® each hour and Aculare® 4 times daily. Patients were examined at day 1 and 4, 1 week and 1 month postoperatively. At each examination, UCVA, BSCVA and slit lamp biomicroscopy were recorded. Objective refraction, keratometry and corneal topography were recorded at 1 month.

RESULTS

The results are summarized in table 1. The mean age of the patients was 54 years (range, 37-81). The interval between PKP and treatment of astigmatism ranged from 16 to 39 months. The mean preoperative UCVA was 0.15. The mean preoperative BSCVA was 0.54. The mean CU index was 40 %.

Case 1: LASIK was performed in order to correct the residual myopia and to reduce astigmatism after PKP. This combined treatment for anisometropia and astigmatism resulted in an improvement of UCVA from 0.1 to 0.6 with a CU index improvement from 80 % to 90 %.

Case 2: LASIK was performed in order to correct post-PKP hyperopia and astigmatism. Al-

Tab 1

Case	Eye	Age (years)	Indication for PKP ¹	Interval PKP-treatment	Treatment	Before Treatment				After treatment					
						Subjective refraction	UCVA (decimal)	BSCVA (decimal)	CU index ² (%)	PC acuity (decimal) ³	Subjective refraction	UCVA (decimal)	BSCVA (decimal)	CU index ² (%)	PC acuity ³
1	1	81	PBK ⁴ , AC-IOL ⁵	39	LASIK	-3.50 (-2.50 × 180°)	0.1	0.7	80	20/25 (0.80)	+1 (-2 × 180°)	0.6	0.7	90	20/20 (1.0)
2	2	76	PBK ⁴ , PC-IOL ⁶	19	LASIK	+5.50 (-10 × 140°)	0.05	0.4	0	20/200 (0.10)	0 (-2 × 60°)	0.1	0.4	10	20/125 (0.16)
3	3	61	Complication after PRK	33	LASIK + DTK ⁷	+7.50 (-7.50 × 160°)	0.05	1.0	70	20/32 (0.63)	+2 (-7 × 30°)	0.3	0.5	40	20/63 (0.32)
4	4	53	Sclerocorneal laceration	35	AK + LASIK (2x)	0 (-4 × 60°)	0.05	0.2	10	20/125 (0.16)	+0.50 (-2 × 140°)	0.3	0.7	0	20/200 (0.10)
5	5	39	Perforated corneal ulcer	16	LASIK	+4 (-3 × 30°)	0.2	0.6	80	20/25 (0.8)	0	0.7	0.7	20	20/100 (0.20)
6	6	30	Keratoconus	34	AK	-0.50 (-2.50 × 180°)	0.4	0.4	50	20/50 (0.4)	-2 (-3 × 25°)	0.5	1.0	70	20/32 (0.63)
7	7	30	Keratoconus	16	AK	-0.75 (-3 × 120°)	0.5	0.8	0	20/160 (0.125)	-1.75 (-5 × 135°)	0.1	1.0	10	20/125 (0.16)
7	8	37	Complication after RK	9	AK	+1 (-3 × 15°)	0.4	0.7	10	20/125 (0.16)	0 (-2 × 50°)	0.7	0.9	90	20/25 (0.80)
8	9	60	Cornea decompensation	19	AK	+3 (-5 × 100°)	0.2	0.5	0	20/160 (0.125)	+2.50 (-2.75 × 100°)	0.4	1.0	50	20/50 (0.40)

¹ PKP: Penetrating keratoplasty

² CU index: corneal uniformity index

³ PC acuity: predicted corneal acuity

⁴ PBK: pseudophakic bullous keratopathy

⁵ AC-IOL: anterior chamber intraocular lens

⁶ PC-IOL: posterior chamber intraocular lens

⁷ DTK: diode thermal keratoplasty

though subjective refraction decreased dramatically, visual acuity remained the same. The reason for that is to be found in the CU index, which was poor preoperatively and remained poor postoperatively.

Case 3: This patient was referred because of bad results after PRK for +5 D hyperopia. Visual acuity of that eye could be corrected up to 1.0 with contact lenses. However, the patient was completely contact lens intolerant after PRK. Post-PKP hyperopia and astigmatism were treated by LASIK, reducing the amount of astigmatism from 7.50 D to 3.00 D. Because BSCVA improved very poorly (0.2 with optimal refraction of +5.50 (-3 x 180°), a diode thermal keratoplasty (DTK) was performed at this stage. After this procedure the cornea became more regular, but the amount of astigmatism increased to 7 D (optimal refraction was +2 (-7 x 30°). UCVA improved however to 0.3, allowing binocular vision. The patient considered this result as satisfactory.

Case 4: This case concerns a traumatic corneoscleral laceration with loss of lens, iris and vitreous in an eye previously treated by RK for myopia. After the initial wound closure, the patient needed 4 other surgical interventions: vitrectomy, trabeculectomy, implantation of an iris diaphragm IOL and finally a corneal graft. BSCVA was 0.2 with -4 x 60°. Because of the low-grade astigmatism, AK was proposed. Because the refraction remained unchanged, LASIK was added. After LASIK treatment and a complementary reshaping, UCVA improved not higher than 0.3 but BSCVA improved to 0.7.

Case 5: In this patient post-PKP anisometropia and astigmatism were corrected by LASIK in order to improve her poor UCVA of 0.2. UCVA improved to 0.7 though CU index decreased from 80 % to 20 %. This was due to the presence of a postoperative paracentral irregularity within the 3 mm corneal central zone, which in case of this patient didn't affect her central vision.

Case 6: This patient underwent PKP in both eyes because of keratoconus. In one eye AK for post-PKP astigmatism did not result in an improvement of the cylinder but in an improvement of the CU index from 50 % to 70 % and a dramatical improvement of the BSCVA.

The contralateral eye however presented a similar subjective refraction compared to the oth-

er eye but with a CU index of 0 %. BSCVA was very good preoperatively and remained very good postoperatively even with a slightly worsening of the astigmatism but with a slight improvement of the CU index.

Case 7: This patient was referred to our department for PKP after RK for moderate myopia with severe vascularisations, scar formation and thinning of the cornea at the level of the incisions. Post-PKP astigmatism further treated by AK resulted in an increase of both UCVA and BSCVA.

Case 8: Post-PKP astigmatism treated with AK resulted in a decrease of the astigmatism from 5 D to 2.75 D. Spectacle correction of the treated eye and of both eyes was very successful.

In this series, the mean postoperative UCVA was 0.34 and the mean postoperative BSCVA was 0.74. The mean postoperative CU index was 48 %. Compared to the preoperative condition, the mean gain in UCVA was 0.19 and was 0.20 for the BSCVA.

BSCVA decreased in one eye and UCVA increased in all eyes. Astigmatism decreased in all eyes, except in both eyes of patient 6. No complications like dehiscence of the wound, intra- or postoperative complications were observed in this series.

DISCUSSION

The most recent surgical approaches for the correction of post-PKP astigmatism are arcuate incisions, photorefractive keratectomy (PRK) and laser in situ keratomileusis (LASIK).

A certain number of authors published their results for the correction of post-PKP astigmatism (14, 16, 20). They claimed to be able to correct 5 to 9 D of astigmatism post-PKP.

Ocular perforation as complication after AK post-PKP has been described by Weller et al. (24).

With the advent of the Excimer Lasers, PRK was applied on eyes with high degrees of astigmatism after PKP (4, 22). These authors achieved a mean reduction in the preoperative post-PKP astigmatism of 2 to 3 D. Haze and regression were very important in all series (up to 40 % grade 4 haze). For this reasons, PRK was abandoned in favour of LASIK as option to treat astigmatism after PKP. The mean improve-

ment in astigmatism after LASIK was in the same range as for PRK but without the complication of haze and regression (2, 3, 7, 9, 15).

Rashad (18) reported a very high reduction in cylinder (88.2 %) by performing enhancements in 10 out of 19 eyes in his series. Kwitko et al. (13) performed retreatment in 42.9 % of eyes, resulting in a poor further improvement of the cylindrical correction. We did perform only one post-LASIK enhancement treatment in our series (case 4).

In this study, flap cut and excimer laser ablation were performed at the same time. Because the flap cut may decrease intracorneal mechanical forces, some authors (5, 6, 23) advocated to perform the LASIK procedure in two steps. Donnenfeld et al. (8) and Malecha et al. (15) still prefer a one-step procedure and secondary enhancement if necessary. Till now, there are no data comparing the efficacy of the one-step and the two-steps procedure.

Since these treatment modalities are performed in stitch-free corneas, one may expect the keratometric values to change with time. This has been predicted in one study where progressive post-LASIK changes in refraction and topography was found in 35.7 % of the cases (13).

Intra-operative complications described in the literature using LASIK technique after PKP are button hole (2 cases) (9, 13), epithelial ingrowth (2 cases) (13), diffuse lamellar keratitis (DLK) (15), free flap and postoperative retinal detachment (13). In our small series we did not encounter any type of these complications.

Corneal topography after PKP is not easy to interpret. Using the EyeSys topography, the most appropriate programme to evaluate PKP is the Holladay Diagnostic Summary (HDS) (12). The corneal uniformity (CU) corresponds to the number of points from the distortion map presenting the same maximal refractive power. The predictive corneal acuity is function of the defocus of each point studied on the cornea compared to the point with the maximal refractive power. Depending on the place of that point of maximal refractive power within the pupil size of 3 mm or 6 mm, visual acuity is deducted. Considering the calculation, it is to be expected that PC acuity is a very bad parameter to

estimate BSCVA in cases of PKP. This is also what we found. In our series PC acuity was within 1 line of prediction in 23 %, within 2 lines in 41 % and within 3 lines in 70 %. These results are very poor when compared to those obtained after PRK: PC acuity: 70 % within 1 line, 90 % within 2 lines and 95 % within 3 lines (12).

The mean preoperative CU index was 40 %. The mean postoperative CU index is 48 %. This slight improvement in the mean CU index resulted in a mean BSCVA improvement of 0.20 and a mean improvement in UCVA of 0.19. The improvement in UCVA in case of post-PKP correction of anisometropia and/or astigmatism is a very important parameter for the evaluation of success since a decrease in anisometropia and/or astigmatism will optimize patient's binocular vision in daily life.

CONCLUSION

AK remains a valuable technique for the correction of post-PKP astigmatism provided this astigmatism is of low-grade and more or less regular (≤ 5 D). LASIK is a better option in case both anisometropia and astigmatism have to be corrected. The choice of the technique will also depend on the binocular status of the patient, more in particular on the degree of anisometropia. The Holladay Diagnostic Summary may be useful though not highly reliable in predicting visual acuity post-PKP based on the corneal distortion.

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