European Journal of Ophthalmology / Vol. 17 no. 6, 2007 / pp. 954-960

Extended silicone oil tamponade in primary vitrectomy for complex retinal detachment in proliferative diabetic retinopathy: A long-term follow-up study

YUN-DUN SHEN[1,2], CHUNG-MAY YANG[1]

[1]Ophthalmology Department, National Taiwan University Hospital, Taipei
[2]Ophthalmology Department, Cathay General Hospital, Taipei, Taiwan - Republic of China

PURPOSE. *To investigate long-term anatomic and functional results of extended silicone oil (SO) tamponade in primary vitrectomy for patients with proliferative diabetic retinopathy (PDR) and complex retinal detachment (RD).*

METHODS. *From January 1999 to June 2005, clinical records of consecutive patients with PDR who underwent primary vitrectomy with extended SO tamponade for complex RD were retrospectively reviewed. Main outcome measures included anatomic outcome, functional outcome, and postoperative complications. Statistical analyses were used to determine factors affecting anatomic and functional outcomes and to evaluate the potential adverse effects on vision from long-term oil tamponade.*

RESULTS. *Fifty-four eyes of 45 patients (18 male and 27 female) were included in this series. All patients underwent follow-up ≥12 months (28.2±15.1 months; range: 12 to 69 months). Anatomic success was achieved in 85.2% at the third month postoperatively and 83.3% at last follow-up. Breaks with adjacent unreleased traction was identified as the only variable associated with final anatomic success (OR=0.173, p=0.024). Best-corrected visual acuity (BCVA) improved or remained unchanged in 89% at the third month postoperatively and in 78% at last follow-up. Ambulatory vision was achieved in 41% at the third month postoperative and 44% at last follow-up. Preoperative BCVA was identified as the only variable statistically associated with final BCVA (p<0.001) (multivariate analysis). The change of BCVA from the third month to last follow-up has no correlation with follow-up duration in the 45 eyes with final anatomic success (Pearson correlation coefficient = –0.022, p=0.888). Postoperative complications included peri-silicone oil proliferation in 4 eyes, neovascular glaucoma in 4 eyes, oil migration into anterior chamber in 9 eyes, and pupillary-block induced IOP elevation in 5 eyes.*

CONCLUSIONS. *Prolonged SO tamponade may provide anatomic success and functional stability after primary diabetic vitrectomy. Significant complications compromising visual prognosis were uncommon with prolonged SO tamponade. (Eur J Ophthalmol 2007; 17: 954-60)*

KEY WORDS. *Silicone oil, Vitrectomy, Proliferative diabetic retinopathy, Retinal detachment*

Accepted: June 27, 2007

INTRODUCTION

Despite advances in vitreoretinal surgery for treatment of severe proliferative diabetic retinopathy (PDR), serious postoperative complications, such as recurrent retinal detachment (RD), neovascular glaucoma (NVG), hypotony with subsequent phthisis bulbi, and fibrinoid syndrome, may make many cases unsalvageable (1). Because sili-

1120-6721/954-07$15.00/0

cone oil (SO) has the potential benefit of early visual rehabilitation, maintenance of retinal tamponade, prevention of hypotony (2), and lowering incidence of recurrent bleeding or rubeosis (3-5), it has been used in diabetic vitrectomy in an attempt to reduce those severe postoperative complications (5-10). While most previous studies focused on the role of SO in secondary surgery (3, 5, 7-9, 11-14) few reports on SO use in primary surgery exist in the literature (6, 10).

In eyes that have undergone successful surgery with the use of SO tamponade, it has been common practice to remove the oil when clinical conditions become stable in order to avoid possible oil-related complications (13-16). However, premature SO removal may increase the possibility of recurrent vitreous hemorrhage (VH), recurrent RD, and phthisis bulbi (15, 16). Further, removal of SO may take the risk of sudden visual loss in rare cases (17).

Considering the possibility of missed breaks created during diabetic vitrectomy and the severe complications of recurrent RD, we used SO tamponade permanently in some difficult cases when judged necessary. The purpose of this study is to evaluate the advantages and complications of prolonged SO tamponade in primary diabetic vitrectomy in 54 eyes of 45 patients.

MATERIALS AND METHODS

Demographics and preoperative status

The medical charts of consecutive patients with PDR who received SO injection during primary pars plana vitrectomy (PPV) at National Taiwan University Hospital during the period of January 1999 to June 2005 were reviewed retrospectively. Demographics (age and gender), preoperative ophthalmologic status, including best-corrected visual acuity (BCVA), intraocular pressure (IOP), lens status (phakic, pseudophakic, or aphakic), presence of dense VH obscuring fundus examination, circumferential extent of fibrovascular proliferation (FVP) and RD, and presence of FVP extending to equatorial area (equatorial traction), and other abnormal findings such as rubeosis and NVG were recorded. The vitreoretinal status was assessed preoperatively with indirect ophthalmoscope or intraoperatively when VH obscured ophthalmoscopic examination. The extent of FVP and RD was graded according to the number of fundus quadrants involved (inferotemporal, inferonasal, superotemporal, and superonasal to the optic disc). Cases with postoperative follow-up less than 12 months were excluded. Institutional review board approval was not required for this retrospective record review.

Surgical procedure

Informed consent was given preoperatively. All surgeries were preformed by the same surgeon (C.-M.Y.). The indications for SO injection included widely distributed multiple breaks (pre-existing and iatrogenic), or breaks or possible breaks created in the presence of unreleased traction. All patients underwent a standard three-port PPV with removal of FVP. Visually significant cataract was removed and intraocular lens was implanted. Scissors were used to divide the FVP from the retina. Forceps were used to gently lift the proliferative tissue from the disc to release traction and to facilitate identification of the surgical plane. Posterior hyaloid removal was performed to the farthest periphery possible. An effort was made to stop any bleeding and to remove any residual preretinal blood. After releasing as much traction as could be done safely, air-fluid exchange was performed to flatten the retina. Laser photocoagulation was performed around any breaks (preexisting or iatrogenic) and across the peripheral retina. A Gortex encircling band was then placed. A segmental scleral buckle was added to counteract unreleased equatorial traction if necessary. SO of 5000 centistokes was injected before wound closure.

Cataract extraction with intraocular lens implantation was performed at least 3 months postvitrectomy in eyes with anatomic success and expected functional improvement. Laser capsulotomy was performed in all cases with thickened anterior or posterior capsule. Cases with NVG received cyclocryotherapy. All cases with SO which migrated into the anterior chamber (AC) and jeopardized the cornea received further surgery to remove the SO in AC.

Main outcome measures

Anatomic and functional outcomes. Anatomic success was defined as complete retinal attachment and recorded as initial anatomic success (third month postoperative) and final anatomic success (last follow-up). Functional outcomes were assessed by BCVA measured preoperatively, at the third month postoperatively, and at last follow-up. Ambulatory vision was defined as a BCVA ≥20/1000.

Complications. IOP elevation was defined as IOP >24 mm Hg and recorded as immediately postoperative (during admission), late-onset (after discharge), and long-term elevation. Rubeosis, band keratopathy, SO migration into AC, cataract progression, and peri-silicone oil proliferations were recorded.

Statistical analysis

Data analysis was performed using SPSS™ statistical program (Chicago, IL, Version 13.0 for Windows). Univariate analysis with logistic regression was employed to identify variables associated with final anatomic success; only variables with statistical significance ($p<0.05$) or showing a trend towards significance were entered into the multivariate analysis. Univariate analysis with linear regression was employed to identify the variable associated with final visual outcome; only variables with statistical significance ($p<0.05$) or showing a trend towards significance were entered into the multivariate analysis. To evaluate the potential retinal adverse effect from long-term SO tamponade, bivariate correlation between BCVA change (from the third month postoperatively to last follow-up) and duration of SO tamponade were performed in eyes with final anatomic success.

RESULTS

Demographics and preoperative status

Fifty-four eyes of 45 patients received surgery (18 males and 27 females). Patient ages ranged from 23 to 69 years (mean: 48.0±12.0 years). Follow-up ranged from 12 to 69 months (28.2±15.1 months). Three eyes were pseudophakic, and all others were phakic. Rubeosis with NVG was noted in one eye. Dense VH that obscured preoperative fundus examination was noted in 4 eyes. Thirteen eyes had FVP in two quadrants and 17 eyes had FVP in three quadrants; four quadrants were involved with FVP in 24 eyes. Tractional retinal detachment (TRD) was observed in all eyes, of which table-top tractional detachment (TTT) appeared in four. Twenty-one eyes had RD in two quadrants and 10 eyes had RD in three quadrants; RD extending to all four quadrants was noted in 23 eyes. Retinal breaks were identified preoperatively or at the beginning of surgery in 28 eyes. Macular detachment was noted in 44 eyes.

Surgical indications and management

Multiple breaks (pre-existing or iatrogenic) were present in all eyes. Breaks or possible breaks created in

TABLE I - UNIVARIATE ANALYSIS WITH LOGISTIC REGRESSION

	P	OR	CI (95%)	
			Lower	Upper
Age	0.882	1.005	0.946	1.066
Gender	0.269	0.441	0.104	1.881
FVP (2 quadrants)	0.610	1.0		
FVP (3 quadrants)	0.439	0.389	0.036	4.248
FVP (4 quadrants)	0.320	0.317	0.033	3.051
RD (2 quadrants)	0.917	1.0		
RD (3 quadrants)	0.687	0.667	0.093	4.797
RD (4 quadrants)	0.779	0.792	0.155	4.040
Combined TRD/ RRD	0.209	2.632	0.582	11.899
Macula involvement	0.538	2.000	0.221	18.112
Equatorial traction	0.999	338122646.020	0.000	.
Pre-operative BCVA	0.195	1.307	0.871	1.960
Break with adjacent unreleased traction	**0.024**	**0.173**	**0.038**	**0.791**
Lens surgery	0.294	2.200	0.505	9.582
Follow-up time	0.874	0.996	0.950	1.044

OR = Odds ratio; CI = Confidence interval; FVP = Fibrovascular proliferation; RD = Retinal detachment; TRD = Tractional retinal detachment; RRD = Rhegmatogenous retinal detachment

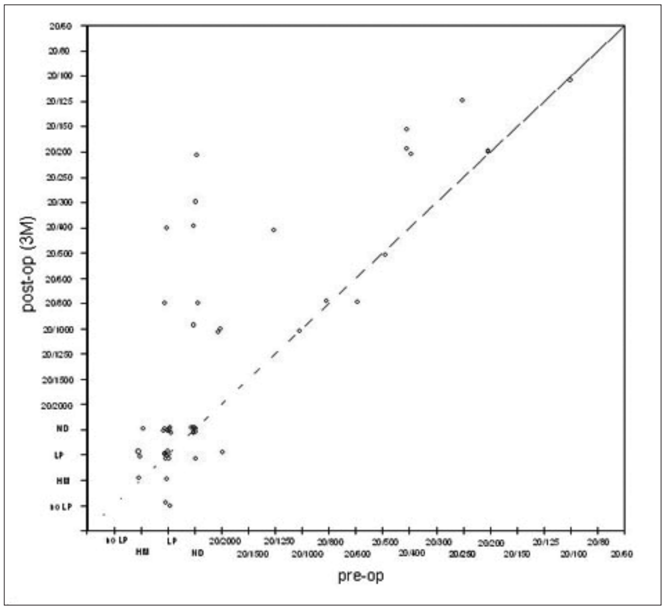

Fig. 1 - *The correlation of preoperative best-corrected visual acuity (BCVA) and 3-month postoperative BCVA of the total 54 eyes included in this study.*

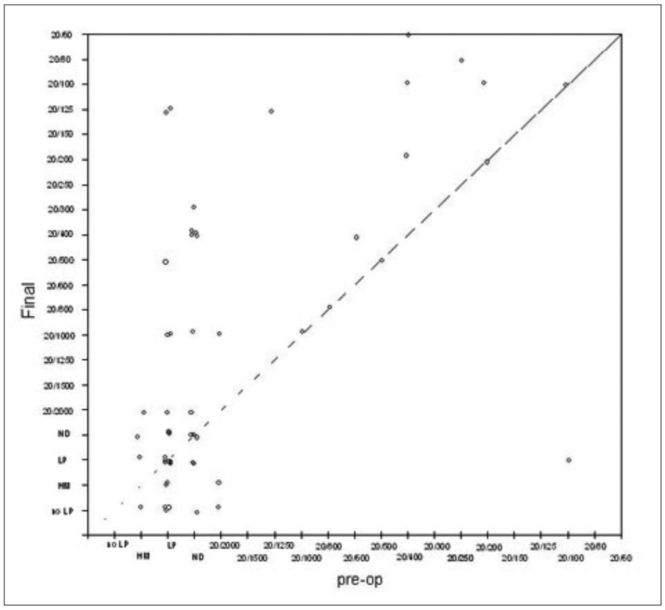

Fig. 2 - *The correlation of preoperative best-corrected visual acuity (BCVA) and final BCVA of the total 54 eyes included in this study.*

the presence of unreleased traction were noted in 12 eyes. Primary cataract extraction with intraocular lens implantation was performed in 10 eyes due to visually significant cataract. Secondary cataract extractions with intraocular lens implantation were performed in 28 eyes.

Main outcome measures

Anatomic and functional outcomes. Forty-six (85.2%) eyes achieved anatomic success at the third month postoperatively and 45 (83.3%) eyes achieved final anatomic success at last follow-up. Most anatomic failures occurred within 3 months and only one eye developed recurrent RD after 3 months. Of the 9 eyes with final anatomic failure, 4 eyes had breaks or possible breaks created in the presence of unreleased traction; breaks with adjacent unreleased traction were identified as the only variable associated with final anatomic success (OR=0.173, p=0.024) (Tab. I).

The correlation between preoperative BCVA and third month postoperative BCVA is demonstrated in Figure 1, in which 48 (89%) eyes showed stationary or improved vision 3 months postoperatively; 42 (78%) eyes showed stationary or improved vision at last follow-up as compared to preoperative BCVA (Fig. 2). Twelve (22%) eyes had ambulatory vision preoperatively, and 22 (41%) eyes achieved ambulatory vision at the third month; at last follow-up, 24 (44%) eyes achieved ambulatory vision. Under univariate analysis, age (p=0.041), RD in all

TABLE II - UNIVARIATE ANALYSIS WITH LINEAR REGRESSION

	Beta	P
Age	**-0.279**	**0.041**
Gender	-0.038	0.783
FVP (2 quadrants)		
FVP (3 quadrants)	-0.278	0.109
FVP (4 quadrants)	-0.280	0.107
RD (2 quadrants)		
RD (3 quadrants)	-0.163	0.254
RD (4 quadrants)	**-0.433**	**0.003**
Combined TRD/ RRD	0.077	0.583
Macula involvement	**0.432**	**0.001**
Equatorial traction	0.084	0.548
Pre-operative BCVA	**0.601**	**0.000**
Break with adjacent unreleased traction	-0.110	0.430
Lens surgery	0.044	0.753
Follow-up time	0.263	0.055

FVP = Fibrovascular proliferation; RD = Retinal detachment; TRD = Ttractional retinal detachment; RRD = Rhegmatogenous retinal detachment four quadrants (p=0.003), macular involvement (p=0.001), and preoperative BCVA (p<0.001) were identified as variables associated with visual outcome (Tab. II). Putting the four variables into multivariate analysis, only preoperative BCVA was identified as variable associated with visual outcome (beta=0.601, p<0.001).

Of the 45 eyes with final anatomic success, 41 eyes (91.1%) had improved or stationary vision from the third month postoperatively to last follow-up. Bivariate correlation of the change of BCVA (from the third month postoperative to last follow-up) and the follow-up duration in the 45 eyes with final anatomic success showed no statistical significance (Pearson correlation coefficient=–0.022, p=0.888).

Complications. All phakic eyes showed cataract progression. Fifteen (27.8%) eyes had immediate postoperative IOP elevation. Fifteen (27.8%) eyes had late-onset IOP elevation, of which four were due to NVG and five were due to pupillary block. Thirteen (24.1%) eyes in this series developed long-term IOP elevation. SO migrated into AC in five eyes after vitrectomy and in another four after secondary cataract extraction. Peri-SO proliferation was noted in four eyes. No eye had postoperative recurrent VH blocking visual axis.

DISCUSSION

Recurrent RD after primary vitrectomy in PDR is usually extensive and may render the affected eye inoperable (1). It is therefore crucial in PDR cases to avoid recurrent RD after primary vitrectomy. In this series, final anatomic success was achieved in 83.3%, and ambulatory vision was obtained in 44%. Except for Gonvers' series, in which ambulatory vision was achieved in 61% (10), our results were similar to or slightly better than previous studies (5, 7, 10, 12, 14). Although comparison with previous series is difficult, our study demonstrated a satisfactory result in a significant number of difficult cases.

An important advantage of SO tamponade over gas tamponade is the clear media immediately after surgery allowing early visual rehabilitation and the feasibility of postoperative photocoagulation. Since recurrent hemorrhage tended to be minor, localized, and not visual axis-interfering, feasibility of postoperative photocoagulation avoids the possibility of extensive inflammation, choroidal thickening, and postoperative angle-closure glaucoma secondary to intensive intraoperative photocoagulation.

Prevention or reversal of rubeosis is also a potential advantage of SO tamponade in PDR cases. It has been suggested that SO may act as a diffusion barrier to angiogenic factors trying to reach the anterior segment (4), although SO does not always prevent neovascularization (7). In this series, one eye with preoperative rubeosis showed complete resolution after surgery. Another eye developed fresh rubeosis postoperatively after secondary cataract extraction with attached retina. This suggested that the protective effect of the SO would only be partial and the violation of the irido-lenticular plane still takes the risk of a neovascular event in an eye with anatomic success.

In treating complicated cases, iatrogenic breaks are common. Multivariate analysis in the present series showed breaks adjacent to unreleased FVP were the only single factor associated with anatomic failure. Since reproliferation may start from areas of unexcised tissues, effort should be exercised to remove all FVP close to retinal breaks. This concern is particularly important in SO-filled eyes where concentrated growth factors beneath the oil provide good environment for membrane growth (18, 19). When complete FVP removal is not possible, high segmental scleral bucking may be used. Retinectomy for traction release was rarely used in this series because the broad vitreoretinal adhesion was usually located posteriorly and thus bleeding was a major concern.

Peri-SO proliferation was a major cause of recurrent RD and poor prognosis after successful surgical reattachment of the retina (20). In our series, this complication occurred in four eyes, of which two cases resulted in recurrent RD. Besides residual preretinal membrane, another factor may also contribute to this complication – a significant amount of blood confined in the preretinal space. While a thin layer of preretinal blood usually is reabsorbed gradually, a thick blood clot or massive recurrent bleeding under the oil may lead to compartmentalization of growth factor in the preretinal space, leading to thick membrane formation, recurrent RD, and surgical failure (15). The presence of massive hemorrhage under SO may be an indication for prompt oil removal and vitreous lavage, followed by SO refill to avoid this complication.

IOP elevation was an apparent complication in this series. The occurrence of IOP elevation was multifactorial and may be different between immediate postoperative and late-onset cases. Immediate postoperative elevation was usually related to the choroidal thickening and ciliary body anterior rotation as a result of postoperative inflammation.

Choroidal thickening and the incompressible nature of SO, as compared to long-acting gas tamponade, may result in AC shallowing and very high IOP elevation in the immediate postoperative period. Aggressive control of postoperative inflammation should reduce this complication. NVG and pupillary block were main causes of late-onset IOP elevation in this series. Of the four eyes with NVG, three occurred after recurrent RD, suggesting anatomic failure itself rather than the use of SO as the key factor in the development of NVG. All of the five eyes with pupillary block were successfully treated with AC irrigation and peripheral iridectomy. Although one rationale for consistent removal of SO in PDR cases is the inevitable late-onset emulsification and the associated IOP elevation (10), in our series, however, with an average of more than 2 years' follow-up, no eyes with anatomic success developed medically uncontrollable long-term IOP elevation. Whether the use of high rather than low oil viscosity in our series contributed to this discrepancy requires further investigation.

Eyes with persistent or recurrent RD after primary surgery often show signs of marked intraocular inflammation, hypotony, and corneal folds. Conversely, when filled with SO, the operated eye usually remained quiet despite a detached retina, and maintained its shape for a prolonged period of time. Therefore, we recommended that SO be infused in eyes destined to surgical failure.

Removal of silicone oil is desirable when the postoperative condition is stabilized since complications, although not frequently seen, may occur during the period of tamponade. Therefore, the eye is probably more stable for a longer period of time if SO can be removed. In this series, however, because of the concern for surgical failure, none of the eyes had SO removed throughout an extended follow-up period. Although there may be concern about the potential retinal toxicity from long contact of SO with the retina, our statistical analysis showed no significant correlation between long-term BCVA change (from the third month postoperatively to last follow-up) and the follow-up duration in eyes with anatomic success. This result suggests that functional outcome may be maintained with long-term oil tamponade. The five eyes in which vision deteriorated after 3 months were due to NVG after secondary lens surgery in one eye, preexisting myopic maculopathy progression in one eye, recurrent RD in one eye, and inflammation-induced pupillary block in one eye; none of these was directly related to the use of SO. Further, the complications of cataract, SO in AC, and angle-closure glaucoma can be properly managed by further surgical intervention.

The chief limitation of this study is the difficulty of standardized grading of complicated PDR cases. Therefore, case-control studies to compare the use of gas with SO is not feasible. However, considering the stable visual outcome throughout an extended follow-up, minor and manageable complications associated with long-term SO usage, as well as the potential risks associated with SO removal (15, 16), with understanding of possible complications and careful case selection, prolonged SO tamponade may be safely used and provide anatomic success and functional stability after diabetic vitrectomy.

The authors have no proprietary interest and receive no research funding.

Reprint requests to:
Chung-May Yang, MD
Department of Ophthalmology
National Taiwan University Hospital
College of Medicine
National Taiwan University
7, Chung-Shan S. Rd.
Taipei, Taiwan, Republic of China
chungmay@ntu.edu.tw

REFERENCES

1. Eliott D, Lee MS, Abrams GW. Proliferative diabetic retinopathy: principles and techniques of surgical treatment. In: Ryan SJ, ed. Retina. Elsevier; 2006: 2438-42.
2. Morse LS, McCuen BW. The use of silicone oil in uveitis and hypotony. Retina 1991; 11: 399-404.
3. Lucke KH, Foerster MH, Laqua H. Long-term results of vitrectomy and silicone oil in 500 cases of complicated retinal detachments. Am J Ophthalmol 1987; 104: 624-33.
4. Charles S, Katz, Katz A, Wood B. Vitreous Microsurgery. 3rd ed. Philadelphia: Lippincott Williams & Wilkins, 2002.
5. Brourman ND, Blumenkranz MS, Cox MS, Trese MT. Silicone oil for the treatment of severe proliferative diabetic retinopathy. Ophthalmology 1989; 96: 759-64.
6. Douglas MJ, Scott IU, Flynn HW, Jr. Pars plana lensectomy,

pars plana vitrectomy, and silicone oil tamponade as initial management of cataract and combined traction/rhegmatogenous retinal detachment involving the macula associated with severe proliferative diabetic retinopathy. Ophthalmic Surg Lasers Imaging 2003; 34: 270-8.

7. Castellarin A, Grigorian R, Bhagat N, Del PL, Zarbin MA. Vitrectomy with silicone oil infusion in severe diabetic retinopathy. Br J Ophthalmol 2003; 87: 318-21.
8. Karel I, Kalvodova B. Long-term results of pars plana vitrectomy and silicone oil for complications of diabetic retinopathy. Eur J Ophthalmol 1994; 4: 52-8.
9. Sima P, Zoran T. Long-term results of vitreous surgery for proliferative diabetic retinopathy. Doc Ophthalmol 1994; 87: 223-32.
10. Gonvers M. Temporary silicone oil tamponade in the treatment of complicated diabetic retinal detachments. Graefes Arch Clin Exp Ophthalmol 1990; 228: 415-22.
11. Rinkoff JS, de Juan E Jr, McCuen BW. Silicone oil for retinal detachment with advanced proliferative vitreoretinopathy following failed vitrectomy for proliferative diabetic retinopathy. Am J Ophthalmol 1986; 101: 181-6.
12. Azen SP, Scott IU, Flynn HW, Jr., et al. Silicone oil in the repair of complex retinal detachments. A prospective observational multicenter study. Ophthalmology 1998; 105: 1587-97.
13. Yeo JH, Glaser BM, Michels RG. Silicone oil in the treatment of complicated retinal detachments. Ophthalmology 1987; 94:1109-13.
14. Scott IU, Flynn HW, Lai M, Chang S, Azen SP. First operation anatomic success and other predictors of postoperative vision after complex retinal detachment repair with vitrectomy and silicone oil tamponade. Am J Ophthalmol 2000; 130: 745-50.
15. Pearson RV, McLeod D, Gregor ZJ. Removal of silicone oil following diabetic vitrectomy. Br J Ophthalmol 1993; 77: 204-7.
16. Kampik A, Hoing C, Heidenkummer HP. Problems and timing in the removal of silicone oil. Retina 1992; 12 (Suppl): S11-6.
17. Newsom RS, Johnston R, Sullivan PM, Aylward GB, Holder GE, Gregor ZJ. Sudden visual loss after removal of silicone oil. Retina 2004; 24: 871-7.
18. Blankenship GW, Machemer R: Long-term diabetic vitrectomy results. Report of 10 year follow-up. Ophthalmology 1985; 92: 503-6.
19. Heimann K, Dahl B, Dimopoulos S, Lemmen KD. Pars plana vitrectomy and silicone oil injection in proliferative diabetic retinopathy. Graefes Arch Clin Exp Ophthalmol 1989; 227: 152-6.
20. McLeod D, James CR. Viscodelamination at the vitreoretinal juncture in severe diabetic eye disease. Br J Ophthalmol 1988; 72: 413-9.