ARTICLE ORIGINAL

Twenty-three-gauge vitrectomy for diabetic tractional retinal detachment: outcomes and prognostic factors

La vitrectomie 23 gauges pour le décollement rétinien tractionnel du diabétique : résultats et facteurs pronostiques.

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Keywords
Diabetic retinopathy, Retinal detachment, Vitrectomy, Risk factors.

Abstract

Purpose. To assess the anatomical results, the functional results, and the complications of 23 gauges vitrectomy in diabetic tractional retinal detachment surgery (TRD). We aimed also to identify the factors influencing these results.
Methods. A retrospective study including 50 patients (50 eyes). All patients were operated by 23 gauges vitrectomy for diabetic TRD. Pre-operative status, surgical procedure as well as post-operative status, were recorded. We studied the anatomical and the functional outcomes as well as their predictive factors (demographic characteristics, diabetes balance, DRT characteristics, the surgical procedure, and pre- and post-operative complications).
Results. The best mean corrected visual acuity was 1.5LogMar ± 0.6 preoperatively. Cataract was present in 24% of cases, rubeosis was present in 10% of cases, neovascular glaucoma was present in 6% of cases, retinal breaks and vitreal hemorrhage were present in 4% and 40% of cases, respectively. The macula was detached in 76% of the cases. A 23G was performed in all cases with silicone oil tamponade. Intraoperative hemorrhage and iatrogenic breaks occurred both in 18% of cases. Functional and anatomical success rates were 80% and 90% respectively. A delay of silicone oil removal more than 6 months (p=0.001, OR=0.842) was a risk factor for functional failure, impaired renal function was a risk factor for anatomical failure (p=0.014, OR=18.724).
Conclusions. Twenty-three gauges vitrectomy was an effective means for the management of diabetic TRD. It ensured satisfactory rates of anatomical and functional success. Long-term post-operative follow-up is mandatory to depict any complications on time.

Mots-clés
Rétinopathie diabétique, Décollement de rétine, Vitrectomie, Facteurs de risque.

Résumé

Objectifs. Evaluer les résultats anatomiques et fonctionnels, les complications du décollement de rétine tractionnel du diabétique (DRT) opéré par vitrectomie 23G, ainsi qu'identifier les facteurs influençant ces résultats.
Méthodes. Etude rétrospective portant sur 50 patients (50 yeux), opérés par vitrectomie 23 G pour DRT du diabétique. Les donnés clinique pré et post opératoire ainsi que le type de chirurgie effectuée ont été notées. Nous avons étudié les facteurs d'échec anatomique et fonctionnel de la chirurgie.
Résultats. La meilleure acuité visuelle préopératoire corrigée était de 1,5LogMar ±0,6. Une cataracte était présente dans 24% des cas, une rubéose irienne dans 10 % des cas, un glaucome néovasculaire dans 6% des cas, une déchirure dans 4% des cas et une HV dans 40 % des cas. La macula était décollée dans 76% des cas. Une vitrectomie 23G a été réalisée dans tous les cas avec tamponnement interne par huile de silicone. Une hémorragie et une déchirure iatrogène peropératoire sont survenues chacune dans 18% des cas. Les taux de succès fonctionnel et anatomique étaient de 80% et de 90% respectivement. Le délai d'ablation de l'huile de silicone supérieur à 6 mois (p=0,001, OR=0,842) était un facteur de risque d'échec fonctionnel, l'insuffisance rénale était un facteur de risque d'échec anatomique (p=0,014, OR= 18.724).
Conclusions. La vitrectomie 23G est un moyen efficace pour la gestion des DRT diabétiques car elle assure des taux satisfaisants de succès anatomique et fonctionnel. Un suivi post opératoire est obligatoire afin de guetter à temps les complications.

Introduction

Diabetes is a public health problem with 415 million adults worldwide being affected [1]. In Tunisia, 12.2% of the adult population is diabetic [2]. Proliferative diabetic retinopathy (PDR) is one of the most common specific complications of diabetes and is the leading cause of blindness in the working adult population [2-6]. Tractional retinal detachment (TRD) represents a serious issue in patients with PDR because of the management difficulties and poor prognosis [7].
When involving or threatening the macula or when a persistent vitreous hemorrhage (VH) is associated, TRD become an indication for surgery by pars plana vitrectomy (PPV).
Despite the advent of 25 and 27 g vitrectomy instruments, the diabetic TRD gold standard surgery remains the 23-gauge (23 G) PPV [8].
Diabetic TRD surgery is among the most challenging vitreoretinal surgeries because of the fragility of the ischemic retina and the presence of extensive fibrovascular membranes The techniques and instrumentation progress such as anti-Vascular Growth Factors (anti-VEGF) injections and the visualization systems improvement, facilitated the management of TRD [9,10]. However, the anatomical and the functional outcomes depend on many other factors such as the detachment characteristics as well as per- and postoperative complications.
The purpose of this study was to describe the anatomical and the

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functional outcomes, as well as the complications of the 23 G PPV (23 G) for diabetic TRD. We aimed also to identify the prognostic factors influencing the results.

Methods

This was a retrospective study including 50 patients (50 eyes), followed in our department between January 2013 and August 2020. All these patients were operated on by 23 G PPV for a diabetic TRD. We included in this study the patients presenting a diabetic TRD requiring a 23G PPV, with or without VH or neovascular glaucoma (NVG) and the patients presenting a diabetic TRD associated with a cataract and requiring a combined surgery (PPV with cataract surgery) having at least three months of follow-up of. We did not include non-diabetic TRD, TRD recurrences, or less than three months of postoperative follow-up.

Preoperative assessment

The patients' medical records were reviewed for age, gender, type, and balance of diabetes (the last glycated hemoglobin), and any previous treatments such as Argon laser retinal pan photocoagulation (RPP), anti-VEGF injections, or cataract surgery.
A complete preoperative examination was performed to determine the best-corrected visual acuity (BCVA), lens status, TRD type and characteristics (location, extension, macula status, associated retinal tears, and the extension of the fibrovascular membranes), or coexisting complications such as rubeosis, NVG and VH. B-scan ultrasonography was performed each time the fundus was not accessible.

Surgical procedures

All surgeries were performed by the same experienced surgeon. They were conducted under general anesthesia. The 23 G PPV was performed with the Stellaris Vitreoretinal Surgical System (Bausch & Lomb Incorporated, Bridgewater, NJ, USA) and a wide-angle viewing system. The vitreous was removed, beginning with the cortical vitreous and hemorrhage, followed by the posterior hyaloid membrane. Peripheral vitrectomy was carried out to relieve anteroposterior tractions. Vitreous base shaving (360°) under scleral depression was performed to remove peripheral cortical gel and release anterior fibrovascular proliferation. Diabetic membrane removal was achieved either with the vitretor, with Internal limiting membrane forceps, or curved scissors. A contact lens was also used for membrane dissection and/or peeling. Fluid/ air exchange was performed in all cases, it helped the Endolaser pan-retinal photocoagulation to be performed up to the far periphery. Laser around holes and breaks were performed if necessary. At the end of the surgery, silicone oil tamponade was used. Sclerotomies were checked for leakage, and if needed, a vicryl suture was applied.
Patients who underwent combined cataract vitrectomy surgery had a phacoemulsification with posterior chamber intraocular lens insertion.

Post-operative assessment

Patients were examined on postoperative day one, 1 week, and 1 month after surgery, then every 3 months. At each visit, a complete examination was performed, including the BCVA measurement, slit-lamp biomicroscopy examination, intraocular pressure (IOP) measurement using applanation tonometry, and fundus examination with a three-mirror lens. An optical coherence tomography (SD-OCT: RTVue XR Avanti) was performed to study more accurately the anatomic outcome with the B-scans.
We defined anatomical success as a reattached retina with clinical and tomographic traction relaxation. We defined functional success by an increase in BCVA postoperatively. We also noted intraoperative complications (iatrogenic breaks and VH) and postoperative complications (cataract, intraocular hypertension, VH, NVG, and recurrence of the detachment).
The studied factors of anatomical and functional failure were summarized in **table I**.
Data were entered and analyzed using IBM SPSS statistics software version 25.

Table I. **Factors that may influence the anatomic and the functional outcomes.**

Anatomic outcome	Functional outcome
· Age and gender · A diabetes duration> 10 years · Unbalanced diabetes with a Hb1ac> 7.5% · Comorbidities (hypertension, renal failure, or coronary artery disease) · History of glaucoma or cataract · Absence of anti-VEGF injections before or during surgery · Absent or incomplete PRP · Characteristics of the detached retina (detachment> 2 quadrants, a detached macula) · Associated lesions (rubeosis, NVG, retinal tears or VH) · Surgery after one month or more · Combined surgery · Intraoperative complication	· Age and gender · A diabetes duration> 10 years · Unbalanced diabetes with a Hb1ac> 7.5% · Comorbidities (hypertension, renal failure, or coronary artery disease) · History of glaucoma or cataract · Absence of anti-VEGF injections before or during surgery · Absent or incomplete PRP · Characteristics of the detached retina (detachment> 2 quadrants, a detached macula) · Associated lesions (rubeosis, NVG, retinal tears or VH) · Surgery after one month or more · Combined surgery · Intraoperative complication · Silicone oil removal after six months or more. · A retinal thickness less than 200 µm. · Postoperative complication.

Results

Preoperative assessment

Demographic features of our patients are summarized in **Table II**.
The BCVA was on average 1.5 logMAR ± 0.6 (finger count at 2 meters) and ranged between 2.5 logMAR (light perceptions) and 0.7 logMAR (2/10). Twenty-nine eyes (58%of cases) had a BCVA ≥1/10. Preoperative PRP was complete in only eight eyes (16% of cases). Intraocular pressure was 14.68 ± 3.43 mm Hg on average. In 44% of cases (22 eyes), TRD extended over two quadrants (**Figure 1**). The macula was detached in 38 eyes (76% of cases).

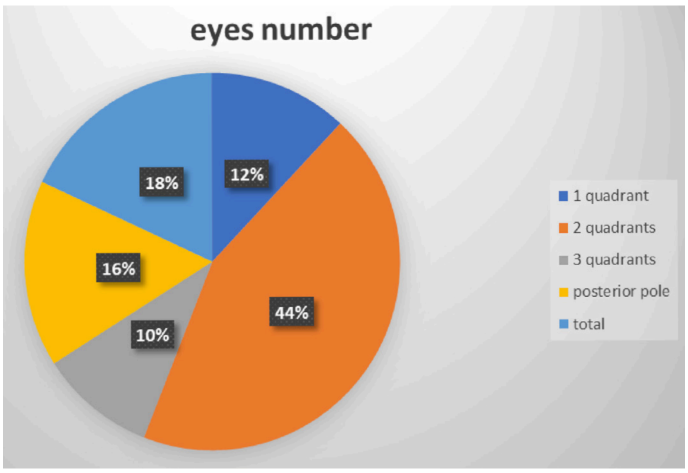

Figure 1. **Patients' distribution according to DRT extension.**

Diabetic TRD was associated with a cataract in 12 eyes (24% of cases), a rubeosis in five eyes (10% of cases), a NVG in three eyes (6% of cases), a VH in 20 eyes (40% of cases) and retinal breaks in two eyes (4% of cases). VH was obturating in seven eyes, moderate in nine eyes, and minimal in four eyes.

Table II. Sociodemographic features of patients.

Features		Results
Age		59 ± 8 years (40 - 80) mediane = 59,5 years-old .
Sex-Ratio		3,16
Diabetes history	Duration	17 ± 7years (between four and 31 years)
General medical history	Balance (HbA1c)	9,6± 1,6 % (6,4% à 14,8%)
	Hypertension	58 %
	Renal failure	10 %
	dyslipemia	24%
Ophthalmological history	Glaucoma	16 %
	Cataract surgery	36 %
	Macular edema	16 %
	Anti-VEGF injections	10 %

Surgical procedure

The surgical delay was 56 ± 41.3 days on average (between five and 180 days). 23 G PPV was associated with phacoemulsification in 17 eyes (34% of cases). Silicone oil tamponade was performed in all patients. An injection of anti-VEGF was performed preoperatively to six eyes (12% of cases) and intraoperatively to two patients (4% of cases). Surgery was complicated preoperatively with VH and with iatrogenic breaks in three eyes (17%) for both.
All patients received RPP postoperatively. Silicone oil was removed in 36 eyes (72%), within 12.2 ± 6.6 months on average (between four and 24 months).

Postoperative assessment

Total reapplication of the retina was obtained in 45 eyes (90%) postoperatively (**figure 2**), while a partial reapplication was found in five eyes (10%), which were successfully reoperated (two of them had a retinectomy with reinjection of Silicone oil).
TRD recurrence occurred in four eyes (12%) within 14.75 ± 22.2 months on average. One eye was successfully reoperated, while a therapeutic abstention was decided in the rest of the cases because of the importance of vitreoretinal proliferation and the loss of vision.
The central retinal thickness measured with the SD-OCT averaged 178.35 µm ± 105.5 (ranging from 80 to 706 µm). It was not statistically linked to the functionnal prognosis.
Renal failure (p = 0.004), NVG (p = 0.013), rubeosis (p = 0.004) hemorrhage and tearing during surgery (p = 0.009) would be the elements of poor anatomical prognosis in the univariate study (**Table III**). Multivariate study identified renal failure as a statistically independent risk factor (p = 0.014) for anatomical failure (OR = 18.7).
In 45 patients, the mean BCVA was 1 LogMAR ± 0.65 (1/10) ranging between 2.5 LogMar (PLMO) and 0.2 LogMar (6.3 / 10). One patient had a VA (visual acuity) of fingers count at 50 cm, two patients had a VA reduced to positive light perception and two had a VA reduced to negative light perception. Postoperative VA ≥ 1/10 was observed in 32 eyes (64%) and improvement in visual function was noted in 40 eyes (80%). A low preoperative VA was predictive of a low postoperative VA (p = 0.001, r = 0.493). The univariate study found four factors that were significantly associated with functional outcomes. A silicone oil removal after 6 months (p = 0.044), the absence anti VEGF injections before or during the surgery (p = 0.003), postoperative complications such as NVG (p = 0.042) or HV (p = 0.038) would have a poor prognosis (Table 3). The multivariate study retained only the silicone oil removal after 6 months (p = 0.001).
Postoperative complications were observed in 33 eyes (66% of cases). Silicone oil-induced glaucoma (SIG) was diagnosed in 25 eyes (75% of complication cases), including four eyes (16%) with preoperative glaucoma. The mean onset delay was 3.79 ± 4.5 months (between one and 24 months). SIG was controlled in all cases with a silicone oil removal performed in 19 eyes (76% of cases) within an average of 11.4 ± 4.5 months, and anti-glaucomatous eye drops.
A postoperative newly formed cataract was diagnosed in 9 eyes (27% of cases) and was treated with phacoemulsification in 7 eyes (77% of these eyes). Postoperative VH was noted in three eyes (9%), within a delay of 9.33 ± 4 months on average (**Figure 3**). It regressed spontaneously in all eyes.
NVG was noted in three eyes (9% of cases) within 2 ± 1 month on average. Hypertension was controlled with maximal anti-glaucoma treatment (four anti-glaucomatous eye drops with oral carbonic anhydrase inhibitor), intra-vitreous injections of anti-VEGF, and then cyclodiode laser if the treatment was not effective.
Some factors may influence the occurrence of the complications. We found that NVG was a statistically independent risk factor of intraoperative bleeding (p <0.001, OR= 2,379). Rubeosis was a statistically independent risk factor of intraoperative tear ((p <0.001,OR = 5.713). Vitrectomy was a statistically independent risk factor for postoperative cataract (p <0.001, OR=3.318). Postoperative vitreous hemorrhage was a statistically independent risk factor for postoperative GNV (p <0.001, OR = 8).

Discussion

Surgery for diabetic TRD is one of the most difficult surgeries of the posterior segment because of an ischemic and fragile retina and the presence of extensive fibrovascular membranes [11].
Recent advances in vitreoretinal surgery including the smaller gauge instruments (23-, 25- and 27-G), wide-angle viewing systems, endo-illumination devices, and intra-vitreous anti-VEGF injections significantly improved the prognosis of TRD [12,13].
Small vitrectomy probes reduce operative time, patient discomfort, conjunctival trauma and shorten recovery delay. Twenty-five and 27 G with the cutting speed of 10,000 cuts/min and the proximity of the cutting hole to the tip of the instrument, allow segmentation and controlled removal of most of the pre-retinal membranes. The reduced diameter of the probes allows access to narrower tissue planes, reduces the risk of ocular hypotension, postoperative hemorrhage, and iatrogenic tears, probably by inducing fewer tractions [11].
Many authors prefer however the 23 G system having all the advantages of the 25 G system, combined with better fluid flow, better suction, more efficient central vitrectomy, and easier peripheral retinal manipulation with a faster injection of silicone oil [14].
Besides, 25 and 27 G sutureless PPV still face technical limitations: more difficult handling of thin and flexible instruments, the small size of the endo-illumination limiting vision quality, and more difficult tamponade with silicone oil [15,16]. Finally, surgery choice depends on the availability of the equipment, the complexity of the case, and the surgeon's preference.
Twenty-three G PPV appears to be a good way to manage diabetic TRD with a high rate of functional and anatomical success. Per and postoperative complications are not negligible and justify adequate monitoring.

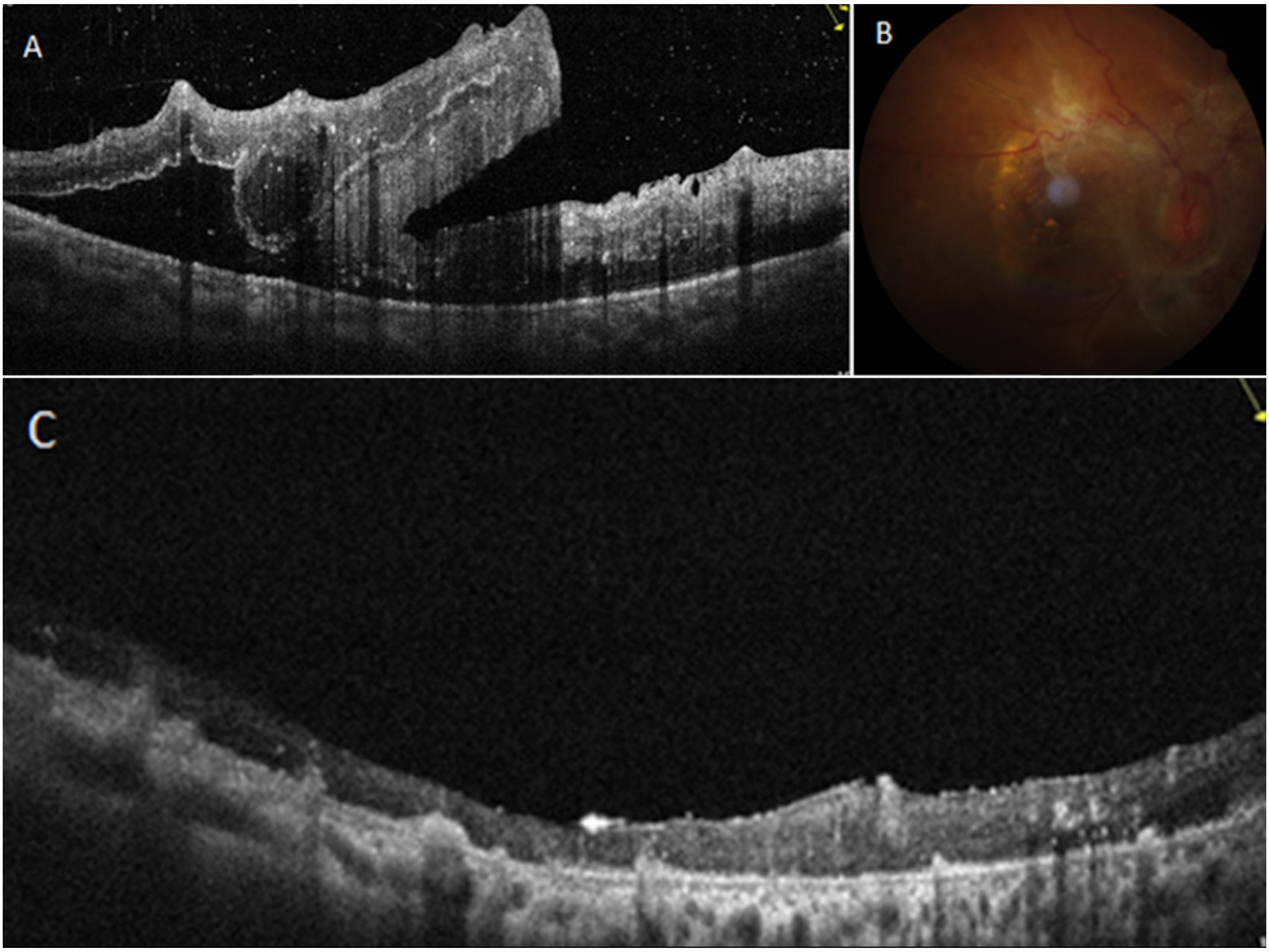

Figure 2. (A, B) TRD of the right eye threatening the macula with a retinal fold, **(C)** shows the postoperative tomographic aspect, the retina is reattached.

Per-operatively, iatrogenic breaks may occur in 41% of eyes according to Oshima et al [17], and in 52.1% of eyes according to Shroff et al [12], especially during the dissection of fibrovascular membranes [18]. The absence of anti-VEGF injections and 20G vitrectomy were risk factors for iatrogenic break occurrence [19,20]. In our study 9 eyes (18% of cases) presented this complication with rubeosis as a risk factor.

To prevent iatrogenic tears, good visibility is required during surgery, we must identify the cleavage planes and the attachment points of the fibrovascular membranes and perform gentle maneuvers during the dissection. The use of small gauge vitrectomy probes reduces the incidence of iatrogenic breaks [21].

Intraoperative dissection could also be complicated by hemorrhage. In our study, it was noted in 18% of cases, which is comparable to the literature [22,23]. Poorly balanced diabetes favors the bleeding. We found that NVG was a risk factor for intraoperative VH in our series. Avery et al found that a preoperative injection of Bevacizumab significantly reduced the risk of bleeding [24].

Complications can also occur postoperatively. Abbas and Burk [25,26] reported SIG in 40.58% and 43% of cases respectively, occurring within 6 months. Pupillary block, infiltration of the trabecular meshwork by silicone bubbles, trabeculitis, synechial angle closure, rubeosis, and migration of emulsified and non-emulsified silicone oil into the anterior chamber were the main causes [27]. In our series, it was diagnosed in 25 eyes (75% of complication cases).

Post-operative VH has been reported in 16 to 55% of cases [28,29,30]. It has been explained by the persistence of traction on the insufficiently dissected neovascular pedicles, by the anterior fibrovascular proliferation, most often located behind the sclerotomies and by extensive fibrovascular proliferation [31]. In our series, we noted postoperative VH in 9% of cases, within 9.33 ± 4 months on average.

Despite the high prevalence of VH, only 5 to 10% of cases require a second surgery [32,33]. Resorption occurs within three to four weeks in pseudophakic eyes and within nine to eleven weeks in phakic. In our study spontaneous resorption of bleeding was noted in all eyes.

Concerning the outcomes, we achieved a postoperative VA ≥ 1/10 in 64% of cases and VA improvement in 80% of the eyes. These results were comparable to those found in many studies reporting a VA ≥1 / 10 in 36.2 to 62.5% of cases and visual improvement in 90% of cases [12,23,34,35-37]. 23 G PPV introduction in 2007, improved considerably the functional success rates from 67% to 100% [12,38].

The factors of poor visual prognosis reported in the literature were the TDR extension, mixed retinal detachment, VH, rubeosis, significant cataract, absence of a prior RPP, and poor initial visual acuity. The presence of any of these factors multiplies the risk of poor final vision by a factor of 1.5 to 3.9 [39].

Williams and al, found that a VA of 5/200 or more was the best predictor of postoperative visual outcome [7]. Ramezani et al [40] reported that eyes with a low initial VA have a much larger margin of visual gain.

Some authors have noted the role of silicone oil tamponade in limiting functional results. This was explained by the complexity of the detachment requiring this tamponade, the frequency of mixed detachment, the complications due to the silicone oil as well as the need for surgery for silicone oil removal [34]. Regarding the central retinal thickness, it was, as we found, weakly correlated

Table III. Univariate analysis of functionnal and anatomical failure predictors after 23G vitrectomy for diabetic tractional retinal detachment.

Features	Predictors of functional failure (p)	Predictors of anatomical failure (p)
Age	0,390	0,848
Sex	0,416	0,323
Diabetes duration >10 ans	0,279	0,666
Hba1C >7,5%	0,691	0,221
Arterial hypertension	0,576	0,625
Renal failure	0,247	**0,004**
Glaucoma	0,572	0,774
Cataract surgery	0,774	0,490
Anti-VEGF injection	**0.003**	0,802
PRP	1,000	0,802
TRD >2 quadrants	0,781	0,259
Detached macula	0,193	0.156
Cataract	0,193	0,944
NVG	0,382	**0,013**
Rubeosis	0,288	**0,001**
VH	0,481	0,163
Retinal tear	0,481	0,538
Surgery delay >1 month	0,490	1,000
Combined surgery	0.717	0.419
Intraoperative hemorrhage	0,279	**0,009**
Intraoperative tear	0,472	**0,009**
Silicon oil removal	0,554	-
Silicone oil removal after 6 months or more	**0,044**	-
Retinal thickness (OCT) <200 µm	0,557	-
Postoperative NVG	**0.042**	-
Postoperative VH	**0.038**	-

with postoperative VA. The ellipsoid zone integrity is the most important prognostic factor in the SD-OCT.
In our series, the multivariate analysis retained only silicone oil removal after 6 months to be a predictive factor of a poor functional result. A low preoperative VA was also predictive of a low postoperative VA (p = 0.001, r = 0.493).
Regarding the anatomical outcomes, La Heij et al [35], found that most patients kept a residual macular detachment for a certain time (mediane of 120 days). In our series, 86.3% of the eyes had a completely reattached retina at the end of follow-up.
Iatrogenic retinal breaks associated with adjacent traction decrease anatomical success. The posterior location of the breaks had the worst prognosis. Retinotomies should be avoided as much as possible because they can initiate recurrences [41].
In our series, renal failure (p = 0.004), NVG (p = 0.013), rubeosis (p = 0.004), VH (p = 0.009) and preoperative breaks (p = 0.009) were associated to poor anatomical prognosis in the univariate study. The multivariate study retained only the renal failure.
The surgery outcomes may improve if an appropriate PRP was performed, it induces new vessels regression, thus helping to prevent future hemorrhages and retinal detachments [42,43]. In our study, 90% of the eyes had PPR which was incomplete in 74% of cases. These rates were comparable to the literature [43]. However, RPP may also cause retinal breaks and may lead to extensive scars, creating firm vitreoretinal adhesions and therefore surgical difficulties in removing them [44].
Preoperative anti-VEGF injections decrease intraoperative bleeding, reduce the use of preoperative Endo diathermia, shorten surgery duration by facilitating the dissection of fibrovascular membranes and decrease the postoperative VH [45]. However, many authors reported the increase of fibrosis risk and the worsening of the TRD [17]. Thus, these injections have been recommended between two and seven days before the vitrectomy [46].

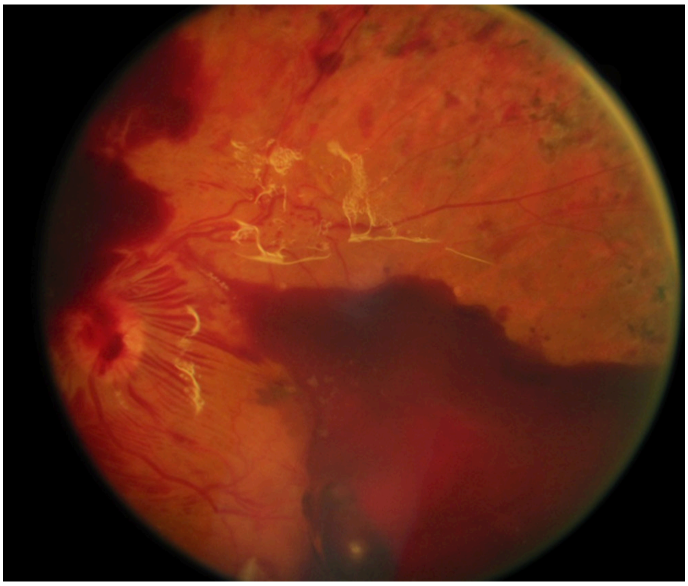

Figure 3. A case of post-operative hemorrhage.

TRD treatment is challenging, it has significantly improved, thanks to small gauge vitrectomy. Careful pre, per, and post-operative management are necessary to improve outcomes and avoid complications on such fragile retina. Our study presents the advantages and limitations of retrospective studies. This type of survey is easy to implement. They allow the generation of hypotheses and can be preliminary to other prospective surveys. This sample cannot, however, be nationally representative due to its limited size. Furthermore, a comparison with other types of endo-ocular microsurgery such as 25 and 27 G vitrectomies allows to better assess the advantages and disadvantages of each technique in this indication.

Competing interests

The authors declare that there is no conflict of interest regarding the publication of this article.

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