Pars Plana Vitrectomy for Treatment of Complications During Phacoemulsification: Indications, Timing and Technique

Vitrectomia Via Pars Plana para o Tratamento de Complicações Associadas à Facoemulsificação: Indicações, Timing e Técnica Cirúrgica

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Recebido/Received: 2022-05-01 | **Aceite/Accepted:** 2022-11-13 | **Publicado/Published:** 2022-12-31

DOI: https://doi.org/10.48560/rspo.27100

ABSTRACT

Phacoemulsification is a procedure with a very low complication rate. Posterior capsule rupture with displacement of fragments is one of the most common complications. However, since it is the most performed ophthalmic surgery worldwide, the prevalence of these complications is high, with potentially vision threatening consequences. Pars plana vitrectomy (PPV) is the gold-standard surgery for removing fragments. The indications for PPV, the timing between phacoemulsification and PPV, and the best PPV technique to be used are subjects of great controversy.

Our aim was to review the previous studies assessing these controversial subjects, aiming a better and easier decision-making and an optimization of the use of PPV for the management of post-phacoemuslification complications.

Search was conducted in MEDLINE using the MeSH keywords "phacoemulsification" and "vitrectomy", filtered from April 2011 to April 2021, resulting in 394 results of which 23 were related to the purpose of this review.

The indications to perform PPV over conservative management, the timing after phacoemulsification, and the PPV technique to be used are multifactorial decisions which depend on the availability of both a surgical facility and a vitreoretinal surgeon. Decision-making is also based on the suspected degree of ocular complications, physician´s discretion, and surgeon's experience in a specific technique. Lens fragments size and density should be reported to help decide whether or not to perform PPV. There is a tendency for better outcomes when PPV is performed in an early setting (if not at the same surgical time as phaco, the first 3 days should be avoided), and small-incision 23- and 25-gauge sutureless PPV is advantageous over 20-gauge, especially regarding glaucoma patients. There is a great amount of bias and more studies with larger sample-size are needed to draw more and reliable conclusions.

KEYWORDS: Phacoemulsification; Vitrectomy.

RESUMO

A facoemulsificação é um procedimento com baixa taxa de complicações, sendo a rutura da cápsula posterior com queda de fragmentos de cristalino umas das complicações mais frequentes. No entanto, o facto de este ser o procedimento cirúrgico oftalmológico mais realizado em todo o mundo, resulta na alta prevalência destas complicações, com consequências potencialmente ameaçadoras da visão. A vitrectomia via pars plana (VPP) é o procedimento *gold-standard* para a remoção dos fragmentos. As indicações para a VPP, o tempo entre a facoemulsificação e a VPP e a técnica cirúrgica a ser utilizada são temas de grande controvérsia.

O nosso objetivo foi fazer uma revisão de estudos que avaliaram as indicações, o *timing* e a técnica cirúrgica a ser utilizada na VPP, de forma a otimizar a sua utilização nas complicações após facoemulsificação.

A pesquisa foi realizada na MEDLINE utilizando os termos MeSH "phacoemulsification" e "vitrectomy", filtrados desde abril de 2011 até abril de 2021, obtendo 394 resultados dos quais 23 se relacionam com o objetivo desta revisão.

As indicações, o *timing* e a técnica cirúrgica da VPP após a facoemulsificação são decisões multifatoriais que dependem da disponibilidade do centro cirúrgico e do cirurgião vitreorretiniano. A decisão é também baseada no critério quanto à gravidade da complicação e na experiência do cirurgião em determinada técnica. O tamanho e a densidade dos fragmentos devem ser relatados de forma a facilitar a decisão. Existe uma tendência para melhores resultados com a VPP precoce (os primeiros 3 dias devem ser evitados, exceto quando realizada no mesmo tempo cirúrgico que a facoemulsificação). A VPP 23- e 25-*gauge* sem necessidade de sutura é vantajosa quando comparada com a 20-*gauge*, especialmente em doentes com glaucoma. Mais estudos e com maior amostra são necessários para otimizar o tratamento destas complicações.

PALAVRAS-CHAVE: Facoemulsificação; Vitrectomia.

INTRODUCTION

Cataract surgery is the most performed ophthalmic surgery worldwide - over the last decades phacoemulsification is the preferred procedure.[1,2] Intraoperative complications during phacoemulsification are relatively uncommon events whose prevalence has been increasing due to the greater number of surgeries performed.[3-7] The most common complication is posterior capsular rupture with vitreous loss and dislocation of lens fragments into the vitreous chamber.[8] Despite the low incidence of retained lens fragments after phacoemulsification (0.1% to 1.6%)[9-13], it has a high prevalence due to the increasing number of cataract surgeries performed. Phacoemulsification can also be complicated by capsular bag detachment or by posterior dislocation of intraocular lens (IOL) (both late-operative or post-operative).[7,14]

Retained lens fragments in the vitreous can be a vision threatening complication, potentially leading to secondary glaucoma, retinal detachment (RD), long-standing uveitis, vitritis, or cystoid macular edema (CME).[15,16]

Upon posterior capsular rupture, the surgeon goal is to complete the phacoemulsification of the remaining fragments before they drop posteriorly, to perform an anterior vitrectomy and to place an IOL either in the posterior or anterior chamber, depending on the capsular support.[17]

When lens fragments remain in the vitreous chamber after finishing cataract surgery, the patient must be referred to a vitreoretinal specialist. Small and especially non-nuclear fragments may sometimes be managed conservatively with medication alone, avoiding the need for a second surgery. However, when facing larger (>2mm) and/or nuclear fragments, the likelihood for developing a severe inflammatory reaction, high intraocular pressure (IOP) or other adverse conditions is greater, warranting a second surgical procedure.[18,19] Pars plana vitrectomy (PPV) is the gold-standard procedure to solve these problems.[20,21]

Nevertheless, there is a great controversy around this topic, namely the indication, timing and technique of the PPV.

This review aims to facilitate decision-making and optimize the treatment of patients with complications during phacoemulsification.

METHODS

The search was carried out in April 2021, through the MEDLINE platform, using de MeSH keywords "phacoemulsification" AND "vitrectomy", filtered from April 2011 to April 2021.

We obtained 394 results, 23 of which were eligible for the purpose of this review.

Articles that address PPV after complicated phaco-

emulsification with regard to the evaluation of indications for PPV, the timing between surgeries, and the surgical technique used were eligible. The survey was conducted in English, Portuguese and Spanish.

PHACOEMULSIFICATION CONSIDERATIONS

The risk of complications during phacoemulsification increases with surgeon´s inexperience, inadequate zonular support (pseudoexfoliation syndrome, trauma, and previous vitrectomy), increased lens density, high axial myopia, insufficient mydriasis, shallow anterior chamber depth and patient´s movements during or after surgery.[22-25]

During complicated phacoemulsification, in order to prevent retinal complications (namely retinal tears and detachment), the surgeon must avoid doing aggressive attempts at intravitreal lens fragments retrieval from a limbal-based approach before a proper and complete vitrectomy.[16,26] These complications result from mechanical traction exerted on the vitreous and vitreous base.[26] Excessive intraocular manipulation may also produce a proportional inflammatory response.[7]

In the case of posterior dislocation of lens fragments, it is important to record the size and density of the retained material. Nuclear lens fragments may carry a worse prognosis for obtaining a good visual outcome than epinuclear or cortical material - retained nuclear fragments are probably related to more complicated cataract surgeries with more vigorous attempts to retrieve fragments, resulting in higher phacoemulsification time and more vitreous traction; nuclear fragments are denser that cortical or epinuclear fragments, leading to an easier dislocation towards the retina with increased likelihood of mechanical damage; vitrectomy for nuclear material removal may be more traumatic. In fact, a study reported the presence of nuclear fragments as the most important prognostic factor regarding visual outcome. Nuclear fragments were associated with significantly worse final best corrected visual acuity (BCVA) compared to cortex or epinucleus fragments (p value=0.007).[27]

If the dislocated lens fragments are too large, the eye may be left aphakic to possibly allow for the removal via the limbus with the aid of perfluorcarbon liquid (PFCL).[19]

Regarding the implantation of an IOL, good capsule and zonular support enable the implantation of a posterior chamber IOL supported by the ciliary sulcus, which showed to predict a better visual acuity compared to an anterior chamber lens or aphakia.[28]

TIMING FROM PHACOEMULSIFICATION TO PPV

The ideal timing between phacoemulsification and PPV is controversial.

A "wait-and-see" approach may be appropriate for small, retained material in the vitreous (especially cortex material). However, an excessive delay in persistent fragment´s removal may worsen the prognosis.[29]

Performing PPV at the same surgical time as phacoemulsification (same-setting) can be a safe and reliable alternative to anterior vitrectomy, with the advantage of a faster recovery of VA (due to less maneuvers in or through the anterior chamber) and less postoperative complications, namely postoperative high IOP. The advantage of PPV lies on the completeness of vitreous removal, allied to low complication rates due to the emergence of small-gauge sutureless techniques.[30] Although it may be a good option to consider PPV primarily, the possibility of performing it at the same surgical time has several limiting factors - uncertainty about the need for posterior vitrectomy, inexperience of the cataract surgeon in performing PPV, inconvenience of referral to a vitreoretinal surgeon and longer operative time) - being a priori limited to institutes with vitreoretinal surgeons.[17] There are studies suggesting that same-setting PPV offers no significant VA advantage over delayed PPV in patients with retained lens fragments.[31,32] However, the higher IOP after delayed PPV may be a disadvantage in patients with advanced glaucoma because it may hasten its progression.[32]

When PPV is not performed in the primary procedure, referral to a vitreoretinal specialist within the first few days after phacoemulsification is essential to allow early surgery to be performed in severe cases or to decide more correctly for a conservative treatment.[33] Noteworthy, intraocular inflammation and corneal edema conditioning poor visualization of intraocular structures make it challenging to perform an early PPV. When an early intervention is warranted (due to uncontrolled glaucoma, moderate to severe uveitis, and hyphema or vitreous hemorrhage), an effort must be made to hasten reduction of corneal edema.[33,34]

Some studies report benefits of an early intervention while others state no differences in outcomes between early and late vitrectomy (table 1).[27,32,34-37] It is difficult to draw conclusions from existing studies due to all the existing bias. For example, patients who undergo early intervention are typically those who have a more complicated condition and increased likelihood of a poor prognosis, as a result of elevated and refractory IOP, larger and/or nuclear lens fragments, associated retinal detachment (RD) or other conditions that may motivate early intervention. In the majority of the studies, there was a small sample-size and the groups of time-periods (from phacoemulsification to PPV) were defined differently among studies, which might have neglected differences in outcomes regarding those same time periods. Despite a lack of statistical difference between early versus late PPV, most of the studies favored the early intervention, while only very few favored the late vitrectomy.[38]

A meta-analysis revealed significantly better outcomes (BCVA, RD, increased IOP and intraocular infection/inflammation) with earlier (from day 3 to day 7 after phacoemulsification) vitrectomy for retained lens material. It was found that PPV performed in 0 to 2 days produced inferior outcomes compared to days 3 to 7, complying with existing recommendations stating that the first few days after cataract surgery are not optimal for PPV, and it is prefer-

Table 1. Comparison between groups regarding studies selected in the research

Reference	Study methodology	N (eyes)	Age (years)	Timing from phacoemulsification to PPV	Final BCVA between groups (*p* value)	Complication rate differences (*p* value)
Paul 2019	Cohort	149	62.1±5.2	2 Groups: • ≤3 days • >3 days	• No statistically significant difference (*p*=0.17)	-
Chan 2020	Cohort	291	73.8±10.6	4 Groups: • ≤1 week • 1-2 weeks • 2-4 weeks • >4 weeks	• Group 2-4 weeks and >4 weeks was predictive of achieving BCVA worse than 20/200 at 6 months when compared to group ≤1 week • Group 1-2 weeks showed no statistically significant difference compared to group ≤1week (*p*>0.05)	-
Scupola 2015	Cohort	40	80.0	2 Groups: • ≤1 week • >1 week	• No statistically significant difference (*p*=0.71)	• RD: no statistically significant difference (*p*=0.54) • CME: group >1 week was associated with higher risk of CME (*p*=0.014*) • IOP: no statistically significant difference (*p*=0.78)
Orlin 2014	Cohort	28	72.9±12.0	2 Groups: • Same-setting (same surgical time) • Delayed-setting: all the other subjects	• No statistically significant difference (*p*=0.132) • Tendency for same-setting group to achieve good vision faster when compared to delayed-setting	• IOP: no statistically significant difference (*p*=0.677) • More eyes in the delayed-setting group had IOP ≥30 at some point during follow-up (*p*=0.05*) • Serous choroidal detachment: no statistically significant difference (*p*>0.99) • CME: no statistically significant difference (*p*>0.99)
Colyer 2011	Cohort	172	75.0±0.8	2 groups: • ≤12 hours • >12 hours	• No statistically significant difference (p=0.97)	-
Moisseiev 2011	Cohort	63	73.0±8.5	3 groups: • ≤1 day • 1-10 days • >10 days	• No statisticaly significant difference (*p*=0.532 for VA 20/40 or better; *p*=0.609 for VA 20/200 or worse)	-

PPV = pars plana vitrectomy; BCVA = best corrected visual acuity; RD = retinal detachment; CME = cystoid macular edema; IOP = intraocular pressure

* statistically significant

able to wait until the cornea clears.[38-42] Macrophage-related inflammation – an important risk factor for increased IOP and long-standing uveitis – is reported to begin after day 3, which may explain the optimal timing being set from day 3 to day 7.[43,44] Wilkinson and Green provided a clinicopathologic perspective by observing increased lens particle-induced inflammatory cells with delayed surgery.[42] Delaying PPV for a few days can be acceptable,[39,45-47] but shortly after that the immunologic response may become advanced, potentially leading to worse outcomes, especially if performed more than 2 weeks after a complicated phacoemulsification.[34,38,48]

Some authors also approached a same-day modality by comparing delayed PPV's outcomes with those obtained

when PPV is performed within 12 hours after phacoemulsification. Same-day PPV may have the benefit of being more convenient for the patients due to less trips to hospital and it can decrease excessive attempts to "rescue" the fragments by the cataract surgeon.[49,50] On the other hand, same-day PPV can be more challenging due to: reduced visualization through an edematous cornea, hypotony, intraocular inflammation, suprachoroidal hemorrhage, serous choroidal detachment, and patient fatigue from multiple surgeries.[36]

Similar visual outcomes and complication rates between same-day and delayed PPV were demonstrated in a study. There was a trend towards smaller fragments removal and smaller-gauge instrumentation in the delayed group, which could falsely lead to better outcomes in this group. Even so, visual outcomes were better in the same-day group (20/30 versus 20/40) in a non-statistically significant way and the authors stated that a larger sample-size is needed to detect a significant 1-line difference in visual acuity.[36] Chan *et al* showed that delaying PPV for more than 2 weeks predicts a BCVA worse that 20/200 at 6 months when compared to PPV in the first week after phacoemulsification.[34]

Regarding post PPV complications, according to several studies, delayed PPV to remove retained lens fragments leads to a high incidence of long-term complications: corneal edema, uveitis, secondary glaucoma, and RD.[10] One study reported a higher risk of CME in the delayed-setting group.[37]

RD and secondary glaucoma are the most serious threats to long-term visual potential.[33] Ho *et al* reported lower risk of secondary glaucoma when performing PPV within 7 days after cataract surgery. Additionally, Orlin *et al* concluded that same-setting (immediately after phacoemulsification) PPV may be advantageous for patients with advanced glaucoma, in which an IOP ≥ 30 mmHg (associated with the delayed group) is not desirable at any time.[32] The risk of developing RD is significantly associated with delayed PPV for more than 30 days (Merani *et al*).[51]

PPV TECHNIQUE

PPV with lensectomy is a well stablished technique for removal of retained lens fragments, preventing further complications and improving the functional outcome.[10,21,22,28,47,52,53] Between 76,4% and 82,6% of patients without pre-existing eye disease achieve a final BCVA of 20/40 or better.[33]

Over the last decades, with the advancement of PPV, different techniques have emerged, mainly regarding the diameter of probes. Transconjunctival sutureless vitrectomy has emerged with the 23- and 25-gauge sclerotomies, in alternative to the classic 20-gauge.[54] Small-incision PPV has several advantages over 20-gauge: self-sealing wounds; reduction of surgical and healing time; less surgical trauma to the conjunctiva and sclera with consequent decrease in postoperative discomfort; less astigmatism induction; and faster visual recovery.[55,56] Small-gauge instrumentation also has the benefit of causing less conjunctival scarring, which may be particularly useful for patients with glaucoma who may need a filtration surgery in the future.[28] Larger incisions are at greater risk of infection, but care must be taken for sutureless wounds that do not self-seal, which could lead to wound leakage, hypotony and endophtalmitis.[33]

Small incision PPV using a vitreous cutter alone or in combination with a light pipe allows the removal of retained lens fragments in selected cases.[54,57] However, when large and/or dense fragments require the use of a fragmatome, a 20-gauge incision is needed since fragmatomes are not yet available in a 23- or 25-gauge version.[55] A study performed by Ho *et al* demonstrated that small-incision vitrectomy has the capability to remove large retained nuclear fragments with the inconvenience of a longer surgery, but based on Wills Eye´s Hospital experience, these lengthy cases can be performed more efficiently by converting into a 20-gauge ultrasonic fragmentation.[54,57]

According to Baker *et al*, determining the size of the retained lens fragments is useful to help predict whether or not to convert to a 20-gauge incision – small-incision PPV will likely be capable of removing cortex or nuclear material with 50% or less of total lens size; conversely, upon more than 50% of nucleus retention, it is prudent to convert to 20-gauge ultrasound fragmentation.[54] As mentioned above, the eye may be left aphakic to facilitate removal of very large fragments via the corneal limbus with the aid of PFCL. The downside is that residual PFCL causes several postoperative complications such as corneal edema, glaucoma, inflammation, and retinal degeneration.[19,58]

Tzamalis *et al* described a safe and efficient technique for removal of lens fragments with a transpupillary intravitreal fragmentation through a small self-sealing limbal incision in order to avoid the use of a 20-gauge scleral port. The final visual outcome was comparable to most of the previous studies on retained lens fragments removal with 20-gauge PPV. Despite these results, the evidence is not strong enough to recommend this technique over wider sclerotomy pars plana fragmentation.[55]

Another innovative technique that emerged recently was the use of a phacoemulsification handpiece through a scleral 20-gauge port in order to remove retained lens fragments.[59,60] Theoretically, the phacoemulsification handpiece can be advantageous due to the torsional oscillations (in addition to the longitudinal oscillations of the fragmatome), avoiding the repulsive effect of a phacoemulsification instrument that only produces longitudinal movement. In fact, Chang *et al* concluded that OZil phacoemulsification handpiece with torsional movement (Alcon Laboratories, Fort Worth, TX) offers better followability (continuous approximation to and aspiration of retained lens fragments with the phaco tip) and purchase of lens material compared to the standard fragmatome, allowing less intraocular manipulation. Thermal scleral wound burns were not reported in this study.[61] Despite the shorter length of the OZil tip (20mm versus 22,5mm for the fragmatome), there is no greater difficulty in reaching fragments at the posterior segment.[62]

Phacoemulsification can also complicate with dislocated IOL. The dislocation of an IOL firstly placed in ciliary sulcus occurs mainly due to insufficient capsular or zonular support. Surgical options for these cases include

repositioning the IOL or removing it and replacing by another one. For this purpose, 23-gauge sutureless PPV has revealed advantageous over standard 20-gauge PPV, giving a much faster surgery, less postoperative discomfort and astigmatism, and faster recovery.[63] If there is capsular support, repositioning the IOL in the ciliary sulcus is the quicker, easier and a less traumatic technique, and so it is the most commonly used.[64,65]

CONCLUSION

The most common complication of phacoemulsification requiring PPV is the dislocation of lens fragments into the vitreous chamber. Upon retained lens fragments, the anterior segment surgeon shouldn't make aggressive attempts at retrieving lens material and a decision must be taken on whether to proceed to a conservative management or to refer to a vitreoretinal surgeon. Lens fragments size and density should be reported since it predicts the need for an invasive intervention. If an IOL is to be placed and there is capsular support, a posterior chamber implantation is easier and less traumatic compared to other techniques.

In a facility with a vitreoretinal surgeon available to perform PPV in the same surgical time as phacoemulsification, it has advantages over anterior vitrectomy. If not possible, a PPV must be scheduled.

Regarding phaco-PPV timing, despite the contradictory results, there is a tendency for better outcomes in patients submitted to an early vitrectomy when excluding the first 3 days after phacoemulsification. These better outcomes are especially evident regarding increased IOP and the need of ocular hypertension medication in the late-setting PPV groups. Delaying PPV beyond 2 weeks after phacoemulsification should be avoided because of the increased immunologic and inflammatory response, which may lead to worse outcomes.

PPV is the gold-standard surgery for removing lens fragments and managing other complications such as displaced IOL. PPV technique will depend on the surgeon´s experience.

Small-incision sutureless PPV (23- or 25-gauge) is advantageous over 20-gauge, with less surgical trauma, faster and sutureless healing, less discomfort and less astigmatism induction. The less conjunctival trauma is particularly relevant when managing glaucoma patients – when a fragmotome is needed, a transpupillary intravitreal fragmentation through a small self-sealing limbal incision is a promising and safe technique that can also spare the conjunctiva (more studies are needed regarding the precise advantages of this technique). If a 20-gauge sclerotomy is performed, the OZil phacofragmentation handpiece has been demonstrated to be more efficient than the classic fragmatome, offering better followability of the lens fragments. Upon a dislocated IOL, small-incision PPV is also advantageous over classic 20-gauge.

The management of phacoemulsification complications with PPV is a very controversial subject and most studies addressing it have several limitations and bias: size and density of retained fragments is rarely reported; tendency to early intervention of more complicated cases with an expected poorer prognosis; timing decision is based on physician discretion, reflecting selection bias and limiting definitive conclusions; groups are divided into discrete time periods; and the samples are typically small sized. This review highlights the need for more studies with an effort to overcome the limitations presented above.

BULLET POINTS

- Posterior capsular rupture with dislocation of lens fragments into the vitreous chamber is a very prevalent complication with potentially vision threatening consequences;
- Despite all the controversial results regarding the ideal timing between complicated phacoemulsification and PPV, most studies show a tendency (not statistically significant) for better outcomes in early-PPV groups;
- Small incision PPV produces less surgical trauma to the conjunctiva compared to 20-gauge PPV and, thus, is the ideal procedure for glaucoma patients;
- Further studies with larger sample size are needed to assess the indications, timing and PPV technique in order to obtain more reliable conclusions.

ACKNOWLEDGMENTS/AGRADECIMENTOS:

Luis Mendonça MD, Rita Gentil MD, José Costa MD, Nuno Gomes MD, Petra Gouveia MD, Rafael Staudt Geraldes MD – Surgical Retina Department of Hospital de Braga; Fernando Vaz MD – Head Chief of Ophthalmology of Hospital de Braga.

CONTRIBUTORSHIP STATEMENT / DECLARAÇÃO DE CONTRIBUIÇÃO:

All authors had a substantial and direct contribution to the elaboration of this article.

All authors participated in the bibliographical search, writing of the manuscript and critical reviewing of the content.

All authors approved the final version of the article.

RESPONSABILIDADES ÉTICAS

Conflitos de Interesse: Os autores declaram não possuir conflitos de interesse.

Suporte Financeiro: O presente trabalho não foi suportado por nenhum subsidio o bolsa ou bolsa.

Proveniência e Revisão por Pares: Não comissionado; revisão externa por pares.

ETHICAL DISCLOSURES

Conflicts of Interest: The authors have no conflicts of interest to declare.

Financial Support: This work has not received any contribution grant or scholarship.

Provenance and Peer Review: Not commissioned; externally peer reviewed.

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