Advances in ophthalmic viscosurgical devices in phacoemulsification

Avanços em substâncias viscoelásticas na facoemulsificação

Charles Kelman performed the first phacoemulsification (PHACO) procedures in the posterior chamber, but because he wanted surgeons to rapidly learn the technique, he chose to luxate the lens into the anterior chamber, where there was always the risk of endothelial damage if viscoelastic substances (VESs) were not used.[1]

In the mid-80s, with the improvement of phacoemulsifiers and the introduction of foldable intraocular lenses (IOLs), VESs, continuous curvilinear capsulotomy, and emulsification of the lens nucleus into the capsular bag, the advantages of PHACO became more clear and the technique gained acceptance among patients.[2,3]

VESs were originally described for use in cataract surgery by Miller and Stegmann in 1980. The first VES on the market was composed of 1% sodium hyaluronate (Healon) and was released by *Pharmacia* in that same year.[4] The main functions of VESs are maintaining anterior chamber volume, especially during capsulorhexis, and protecting the endothelium during PHACO. VESs can also increase intraoperative mydriasis, break synechiae, prevent the formation of free radicals, fragment nuclei (viscofracture), facilitate IOL implantation and/or explantation, act as a mechanical barrier against vitreous loss or haemorrhage, help remove nuclear fragments and cortical debris (viscoexpression), and even facilitate visualisation of the anterior chamber during surgery when used on the cornea (positive lens).

It is essential for cataract surgeons to know the properties of different VESs, with their advantages and disadvantages, in order to select the appropriate product for each patient. It is often preferable to combine the characteristics of the two types of solutions (cohesive and dispersive) during the different stages of PHACO. The well-established soft shell technique, described by Arshinoff in 1999, combines a low-viscosity (dispersive) viscoelastic with a high-viscosity (cohesive) solution in an outer and an inner layer, respectively.[5] However, it is difficult to combine the different physical properties of different solutions in a single agent.

Viscoelastic aqueous solutions are composed of long chains of natural polymers such as sodium hyaluronate, hydroxypropylmethylcellulose (HPMC), and chondroitin sulfate. VESs can be classified according to their physical (or rheological) properties as cohesive or dispersive.

Cohesive solutions have a high molecular weight and long molecular chains (high viscosity), forming a compact mass in the anterior chamber and helping maintain space (and pressurisation) during PHACO. Because of this behaviour they can be easily removed at the end of surgery, but they are also more likely to increase intraocular pressure (IOP) by obstructing the trabecular meshwork.[6]

Dispersive solutions have a low molecular weight and small molecular chains (low viscosity) which provide high tissue adherence. These solutions are more effective in covering and protecting tissues (especially the endothelium) during PHACO. Their main drawback is that they are more difficult to remove after surgery because they are more fragmented, being aspirated in separate parts; however, they do not increase IOP as much as cohesive VESs.[6]

VES selection is based on the surgeon's experience, the surgical case, and available resources. Using more than one type of VES during surgery is preferable in most cases, but it increases the final cost of the procedure. Most surgeons and physicians in training in Brazil do not have access to several types of VES for each patient. Using the correct surgical technique and adequate surgical instruments and phacoemulsifiers can help reduce the need for a variety of solutions.

In the latest survey conducted in Brazil in 2009, HPMC was the VES most commonly used by Brazilian surgeons (60.8%),[7] probably due to the low cost of this dispersive agent and its wide use in the Brazilian national health system (SUS) and in patients covered by private insurance plans. In contrast, most American

and Canadian surgeons use DuoVisc (39%), followed by DisCoVisc (16%).[8] In the latest survey by the American Society of Cataract and Refractive Surgery (ASCRS), 37% of surgeons used DuoVisc (Viscoat and ProVisc), while only 2% used HPMC.[9]

Using a high quality VES can be critical in special situations that require maximum control of the intraoperative environment, including hypermature cataracts, paediatric cases, cornea guttata/Fuchs dystrophy, shallow chambers, zonular weakness, small pupils, and floppy iris syndrome.[7,10] In selected cases, health insurance plans and even the Brazilian national health system should provide a greater variety of VESs for surgery. Using a combination of different VESs, as is done by most surgeons in developed countries, not only improves refractive outcomes but also facilitates the surgical technique and promotes better endothelial protection, which is important for the cornea in the medium and long term.

In recent years the outcomes of PHACO have been improving due to several innovations. With the advent of femtosecond laser-assisted surgery, cataract surgeons have been improving their outcomes. Studies show that previous laser therapy of the lens nucleus (fracture and "softening") reduces the ultrasound time required to aspirate fragments during PHACO,[11] decreases corneal oedema in the early postoperative period, and provides a faster visual recovery, which translates into benefits for patients.

According to some authors, the reduced need for ultrasound during femtosecond laser-assisted surgery means the procedure can be performed using only one type of VES or even without any VES at all.[12] However, VES remains critical for better outcomes, even when laser is used. It is worth noting that in addition to ultrasound times, other variables can affect the corneal endothelium during PHACO, including the biomechanical effects of the saline solution (turbulence and volume) and the direct mechanical trauma caused by surgical instruments, nuclear fragments, and the IOL. VESs minimise the effects of these factors on the endothelium, leading to clearer postoperative corneas.

In conclusion, VESs are critical to the success of PHACO, and a combination of VESs with different characteristics should be made available to most surgeons, especially in more challenging cases.

Rodrigo França de Espíndola
Assistant of Refractive Surgery and Student Program Graduate Assistant , School of Medicine ,
University of São Paulo , São Paulo , SP , Brazil .

References

1. Ambrósio R Jr, Crema A. Tratado Brasileiro de Catarata e Cirurgia Refrativa. In: História da cirurgia de catarata. São Paulo: Cultura Médica, Guanabara Koogan; 2014.
2. Temporini ER, Kara-Junior N, Holzchuh N; Kara-Jose N. Popular beliefs regarding the treatment of senile cataract. Rev Saúde Pública. 2002;36 (3):343-9.
3. Marback RF, Temporini ER, Kara-Junior N. Emotional factors prior to cataract surgery. Clinics. 2007;62(4):433-8.
4. Balazs EA, inventor; Biotrics, Inc, assignee. Ultrapure hyaloronic acid and the use thereof. US patent 4. 141 973. October 17, 1979.
5. Arshinoff SA. Dispersive-cohesive viscoelastic soft shell technique. J Cataract Refract Surg. 1999; 25(2):167–73.
6. Espíndola RF, Castro EFS, Santhiago MR, Kara-Junior N. A clinical comparison between DisCoVisc and 2% hydroxypropylmethylcellulose in phacoemulsification: a fellow eye study. Clinics. 2012;67(9):1059-1062
7. Santhiago MR, Gomes BAF, Gaffree FFP, Varandas VS, Filho AAC. Tendências evolutivas dos cirurgiões de catarata presentes no IV congresso brasileiro de catarata e cirurgia refrativa. Rev Bras Oftalmol. 2009;68(1):13-7.
8. Sorensen T, Chan CC, Bradley M, Braga-Mele R, Olson RJ. A comparison of cataract surgical practices in Canada and the United States. Can J Ophthalmol. 2012;47(2):131-9.
9. Leaming DV. Practice styles and preferences of ASCRS members-2003 survey. J Cataract Refract Surg. 2004;30(4):892-900.
10. Kara-Junior N, Santhiago MR, Kawakami A, Carricondo PC, Hida WT. Mini-rhexis for white intumescent cataracts. Clinics. 2009;64(4):309-12.
11. Alió JL, Abdou AA, Puente AA, Zato MA, Nagy Z. Femtosecond laser cataract surgery: updates on technologies and outcomes. J Refract Surg. 2014; 30(6):420-7.
12. Dick HB, Gerste RD, Rivera RP, Schultz T. Femtosecond laser-assisted cataract surgery without ophthalmic viscosurgical devices. J Refract Surg. 2013;29(11):784-7.