OPESAVER— Super Irrigation System

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ABSTRACT

OPESAVER reduces the surge phenomenon during ultrasonic phacoemulsification. It is composed of a Y-shaped joint (connecting the irrigation tube to the ultrasonic handpiece) to which a silicone tube (3.5 mm in internal diameter, 5 mm in outer diameter, and 2 m in length) is connected. The opposite end of the silicone tube is closed. Making use of the spontaneous compression and inflation, which take place to make the anterior chamber pressure equal to the air pressure within the silicon tube, OPESAVER instantaneously releases the irrigation fluid (entering the silicon tube) into the anterior chamber, thus allowing avoidance of surge and stabilization of the anterior chamber. If OPESAVER is used, stability of the anterior chamber is remarkably improved even when cataract surgery is performed with the irrigation fluid bottle set at a height 30 to 40 cm lower than usual, thus contributing to improving the safety of surgery and promoting postoperative patient recovery. Because the use of OPESAVER involves only a simple change in the pattern of the irrigation side, it can be used in combination with existing methods for manipulation on the aspiration side, and there is no restriction on the type of the apparatus used for aspiration.

TECHNIQUE

OPESAVER consists of a silicone tube (internal diameter 3.5 mm, external diameter 5 mm, length 2 m; Fig. 1). One

HISTORICAL PERSPECTIVE

For the purpose of performing the phacoemulsification (ultrasonic cataract operation) safely without placing excessive burden on a patient,1 the top priority that should be considered is prevention of surge phenomenon. The surgical efficiency (of operation) is reduced, resulting in larger burden on the patients if the prevention (inhibition) depends on the aspiration side.2–6 The mechanical solution for the prevention (inhibition) is almost impossible at present because the duration up to the onset of surge phenomenon is as short as 0.15 second. It is just conceivable for the surgeons to make the irrigation bottle height being lower (that the irrigation bottle height7 must be lowered) because the intraocular pressure during the operation should be maintained as close to the normal level as possible. When I tried and sought the methods to stabilize the anterior chamber effectively, the air entered the anterior chamber and formed bubbles during the operation. When we inserted I/A, the bubbles became smaller due to the irrigation pressure. When the foot pedal was returned to the zero position to stop the irrigation, the bubbles became larger again. Every surgeon who conducted cataract surgery may have had such experience. This led to the development of OPESAVER.8,9

FIGURE 1. OPESAVER.
end of the tube is closed (Fig. 2) and the other end is attached to a Y-shaped joint (Fig. 3). An irrigation tube is connected to the female end of this Y-shaped joint (Fig. 4) and the male end is connected to the female end of phaco or ultrasonic (US) handpiece (Fig. 5).

To understand the system of OPESAVER, we should know the mechanism of the surge phenomenon. To determine the variables of the anterior chamber pressure during the operation, we analyzed them by attaching an electronic tonometer to a simulated anterior chamber and using a device that can transform the electric signals of the tonometer into a graph in real time on the PC (Fig. 6).

Figure 7 shows the internal pressure of anterior chamber in a graph. “A” refers to the condition in which the phaco tip (ultrasonic tip) opens and is released for aspiration. When the phaco tip (nose of ultrasonic tip) is occluded by the nucleus at “a,” the intraocular pressure increases. The bottle height corresponds to the intraocular pressure at “B.” The higher the bottle is raised, the higher the intraocular pressure becomes. If the bottle height is 120 cm, the intraocular pressure at “B” becomes 111 mm Hg, whereas that at “f” and “g” reaches to 160 mm Hg, 10 times higher than the normal intraocular pressure. This sharp increase in intraocular pressure is attributable to the moment of inertia by which the irrigation keeps flowing. When aspiration flow comes into the phaco tip (ultrasonic tip is released) at “b,” the intraocular pressure goes down sharply as in “C.” Though the surge phenomenon has yet to be clearly defined, the author would like to define such plunge (b–e) as the surge phenomenon. In this graph, 0 mm Hg in the broken line is against the atmospheric pressure but the broken line should go up further in the case of actual eyeball because the balance in the posterior capsule is maintained by the vitreous pressure and anterior chamber pressure. When the phaco tip opens again, the condition returns to “D,” which is the same as “A” in the beginning.
FIGURE 6. Mock-up anterior chamber pressure measurement system.

FIGURE 7. Change in anterior chamber pressure.

FIGURE 8. Difference by the height of the bottle.

FIGURE 9. (A) When the irrigation fluid flows into the anterior chamber under normal conditions, aspiration occurs on the corresponding side without resistance. (B) When the nucleus occludes the end of the ultrasonic tip, the pressure changes. (C) When the nucleus is crushed, aspiration resumes.
Though plural causes are intricately involved, the causes of surge phenomenon are roughly classified into a sharp increase in the aspiration flow volume and a shortage of irrigation volume. For example, the irrigation bottle is raised sometimes to prevent the surge phenomenon. However, as shown in Figure 8, marked changes still occur in the internal pressure of anterior chamber because the elevation of bottle neither reduces the plunge in the surge phenomenon nor increases the irrigation volume at the onset of surge. Because irrigation occurs as a free fall from the irrigation bottle, the acceleration rate is always the same so long as the operation is performed on the earth. It takes about 0.5 second for the irrigation volume to reach from zero to the maximum. However, the surge phenomenon that lasts for about 0.15 second is already completed before the lapse of 0.5 second. The higher the bottle is raised, the larger the changes in the intraocular (internal) pressure of anterior chamber.

On the other hand, when OPESAVER is used, the air in A–B (Fig. 9A) is slightly compressed while the irrigation fluid flows into the anterior chamber and the aspiration flows without resistance. When phaco tip (the nose of ultrasonic tip) is occluded by the nucleus, the pressure of irrigation fluid attributable to the irrigation bottle is applied inside the anterior chamber and the air in A–B is further compressed to make the pressure closer to the level in the anterior chamber as much as possible. As a result, a small change occurs as shown in A–C (Fig. 9B) and irrigation fluid flows into the connection tube in an amount (B–C) corresponding to the decrease in the air. Because the pressure in the anterior chamber...
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the anterior chamber as much as possible. The irrigation fluid that is pushed back flows into the anterior chamber to maintain the stability. To sum up, OPESAVER maintains the stability in the anterior chamber by supplementing the irrigation volume that is required to maintain the normal and constant level. Because the pressure in the tube is always higher than the atmospheric pressure, no back-flow of air occurs. Furthermore, considering that the pressure has nothing to do with the direction and position of the tube, a surgeon can arrange the tube freely so as not to hamper the surgical procedure (Fig. 10).

To determine the changes in the anterior chamber pressure, we compared them by attaching the electronic tonometer to a simulated anterior chamber and transformed the electric signals of tonometer into a graph in real time on a PC.

The combination of a small tip and Sovereign (Advanced Medical Optics, Inc., manufactured by AMO, Inc.) was investigated. The aspiration pressure was set at 500 mm Hg, irrigation volume at 30 ml and bottle height at 60 cm (the nose of ultrasonic tip was regarded as 0 cm). The occlusion and release of nucleus were simulated by the open/close of aspiration tube.

The condition by normal tube and that by OPESAVER are shown in Figure 11A and Figure 11B, respectively. As shown in these figures, there is a definite difference.

**REFERENCES**