Wound Strength Comparison of a 5.1-Millimeter No-Stitch With a 7.0-Millimeter Sutured Incision in Human Cadaver Globes

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ABSTRACT
We compared the wound strength of 5.1-millimeter no-stitch incisions with that of 7.0-millimeter sutured incisions in cadaver eyes. Each incision was performed on seven cadaver eyes. Wound integrity was evaluated by subjecting each globe to increasing intraocular pressure (IOP), increasing external pressure, and sudden external pressure. Wound leaks occurred in the 7.0-millimeter-incision globes at consistently lower IOPs and with less external pressure than they did in the 5.1-millimeter-incision globes. We conclude that the 5.1-millimeter no-stitch flap incision has greater wound integrity than the 7.0-millimeter sutured incision when subjected to either internal or external pressures.

One of the most important advances in cataract surgery has been the steady movement to smaller, no-stitch incisions—from the standard 10-

millimeter limbal incision closed with multiple interrupted sutures or one long baseball suture, to the small-incision no-stitch scleral pocket used for phacoemulsification. Many authors have reported decreased postoperative astigmatism and faster visual rehabilitation associated with smaller no-stitch incisions. However, the wound strength of the no-stitch incisions remains a major concern.

Using cadaver eyes, we compared the wound integrity of standard 7.0-millimeter sutured phacoemulsification incisions with that of 5.1-millimeter no-stitch incisions when subjected to internal pressure and external forces.

MATERIALS AND METHODS
Human cadaver eyes were obtained from the Rocky Mountain Lions Eye Bank and stored at −4°C Celsius until use. All eyes were used within 1 month of harvesting. The globes were thawed in warm normal saline for 1 hour prior to use.

With a Styrofoam block holding the eye, a 27-gauge butterfly needle was inserted through the optic nerve into the vitreous cavity. A second 27-gauge needle was inserted through the surgical limbus 2 mm into the anterior chamber. The tubing from each needle was connected via a Y-connector to a single length of intravenous (IV) tubing. This tubing was filled with normal saline and connected to a manometer hung from an IV pole. Each globe was inflated to a pressure of 15 to 25 mm Hg and the pressure was confirmed using a Schiotz tonometer.

In four globes, pressure readings as determined by the manometer at intervals of 20 mm Hg up to 100 mm Hg correlated precisely with Schiotz tonometer readings.
The globes were placed in the precut Styrofoam blocks. Conjunctiva was removed from the incision area by dissection with sharp Westcott scissors. Castroviejo calipers were calibrated using a ruler and then set at the predetermined length for each type of incision. Five-millimeter no-stitch scleral-pocket incisions located 2 mm behind the limbus were created as follows: A partial-thickness (approximately 50%) scleral incision was made with a no. 64 Beaver blade. A no. 66 Beaver blade was then used to create a scleral pocket 1.5 mm into clear cornea. The anterior chamber was entered with a no. 55-30 Beaver blade and the internal opening was enlarged with a 5.1-millimeter keratome blade.

Standard phacoemulsification incisions, 7.0 mm long, located 1 mm behind the limbus, were similarly created, with the following exceptions: a shorter scleral shelf was created with the no. 66 Beaver blade, entering the anterior chamber at Schwabbe’s line or as the tip of the blade became visible through clear cornea. This incision was closed with a 10-0 nylon suture in a running baseball stitch. Care was taken to include suture bites through the posterior shelf and not only the posterior wound lip. Wounds were checked with a cellulose sponge to ensure that no leaks were present. In one 7.0-millimeter incision, a persistent leak remained, and the eye was excluded from the study.

The first phase involved increasing the intraocular pressure (IOP) in each globe with the manometer in increments of 20 mm Hg at 30-second intervals. The globes were then examined under the operating microscope for fluid transudation and wound leaks. These were assessed by placing cellulose sponges at the wound sites during each part of the study.

The second phase consisted of subjecting the globes to external pressure using 28-gram steel ball bearings.

The ball bearings were stacked, adding one at a time, in a cylinder, with their weight resting on the corneal surface of the globes. They were again observed for fluid transudation and wound leaks.

The third phase consisted of dropping a single ball bearing from a height of 50 inches directly onto the globes and noting whether or not the wound ruptured.

Student's t test was used to compare the effects of these three tests on the two types of incisions.

RESULTS

Seven cadaver globes were used for each type of incision. Fluid transudation was defined as a slow but steady transudation of fluid through the posterior bed of the scleral-pocket incision. Such leakage was deemed present, if, after having created a scleral pocket without entry into the anterior chamber and increasing the pressure on the globe, a slow, steady seepage of fluid from the incision was observed. Wound leak was defined as a more substantial gush of fluid, associated with wound gape.

In the first phase, in which the IOP was increased in increments of 20 mm Hg, fluid transudation occurred at an average of 125 ± 32 mm Hg (range, 80 to 170 mm Hg) for the 5.1-millimeter incisions, and at 80 ± 14 mm Hg (range, 60 to 105 mm Hg) for the 7.0-millimeter incisions. Wound leak occurred at an average of 250 ± 48 mm Hg (range, 185 to 300 mm Hg) for the 5.1-millimeter incisions, and at 165 ± 65 mm Hg (range, 80 to 260 mm Hg) for the 7.0-millimeter incisions (Fig 1). These results were clinically significant (P = .010).

In the second phase, in which external pressure was gradually increased, fluid transudation occurred after
an average of 12 ± 1 ball bearings had been stacked for the 5.1-millimeter incisions, and after an average of 3.8 ± 1 ball bearings for the 7.0-millimeter incisions. Wound leaks occurred after an average of 20 ± 4 ball bearings, and 8.4 ± 2 ball bearings had been stacked for the 5.1 and 7.0-millimeter incisions, respectively (Fig 2). These results were clinically significant ($P < .001$).

The actual force on the globe was calculated by measuring the average contact area of the ball bearings on the globes (using fluorescein, the average diameter of contact was 15 mm), and then calculating the force per unit area. Assuming that the pressure was transmitted equally throughout the globe, the average force required to rupture a 5.1-millimeter incision was 3.51 lb/in$^2$; to rupture a 7.0-millimeter incision, 1.89 lb/in$^2$.

In the third phase, in which sudden external pressure was applied, the effects were evaluated in terms of the absence or presence of a wound rupture and whether or not the wound subsequently resealed. Wound leaks occurred in all of the 14 globes at the moment of impact. However, the 5.1-millimeter incisions all subsequently resealed, without further leakage. Six of the seven 7.0-millimeter incisions remained intact after impact (no sutures were broken). However, one such incision had a ruptured suture and iris prolapse through the wound. A second one had a persistent wound leak although all sutures were intact.

**DISCUSSION**

A number of studies have addressed the issue of small-incision cataract surgery and its possible benefits in terms of reduced postoperative astigmatism and inflammation, and speed of visual rehabilitation. These studies have consistently shown the effectiveness of small-incision cataract surgery (3.5- to 6.0-millimeter incisions) in decreasing the amount of postoperative induced cylinder and thereby speeding visual rehabilitation.

Ernest et al., using a pressure transducer to increase IOP, evaluated the strength of limbal incisions and scleral-tunnel incisions with and without internal corneal lips. They concluded that the scleral-shelf incision provided more resistance to internal pressure increases. Our data confirm these results. The pressures measured in both Ernest et al's and our study are well in excess of the usual increases in IOP following cataract surgery.

External pressures, such as eye rubbing or blunt trauma, are also of concern. By placing increasing numbers of ball bearings of uniform weight on the corneas of each globe, we simulated steady external pressure. By dropping ball bearings from a height of 50 inches (the standard height used to measure the impact resistance of lenses), we simulated sudden, rapid external forces, such as might occur from an object striking the eye. Our data clearly show the increased resistance to external forces, both steady and sudden, of the smaller scleral-shelf incision. Even after being subjected to the stress of the dropped ball bearings, the 5.1-millimeter incisions self-sealed.

Small-incision cataract surgery has already proved superior in terms of induced postoperative astigmatism and rapidity of visual rehabilitation. Our study suggests that a 5.1-millimeter no-stitch incision also is superior to a 7.0-millimeter sutured incision in terms of wound resistance to both internal and external pressure.

**REFERENCES**