Octyl 2-cyanoacrylate tissue adhesive in experimental scleral buckling

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ABSTRACT.

Purpose: **In this experimental study, a sutureless scleral buckling was performed by using a tissue adhesive glue to fixate a silicone band to the sclera. In fact, one of the major risks of traditional scleral buckling is accidental perforation of the bulb, which is more frequent when the sclera is extremely thin as it is in newborns or in eyes with high myopia or scleromalacia.**

Methods: **An encircling band of silicone, which is generally anchored to the sclera itself, was sutured in 36 rabbit eyes to three small silastic patches that had been glued to the sclera, at the level of the equator, using octyl 2-cyanoacrylate tissue adhesive. In this manner the anchoring sutures passed through silicone and silicone. The band was tightened to produce buckling of the sclera and its ends were glued together using the same adhesive.**

Results: **Examination of the eyes from 15 days to 6 months after surgery revealed that the buckle was stable, with no signs of slippage, in 33 eyes. In the remaining 3 (one examined after 15 days, 2 examined after 45 days), one of the three support patches had become detached but there was still no evidence of slippage.**

Conclusions: **The stability of the buckle up to six months after surgery suggests that this new adhesive might be used for sutureless surgery in certain types of retinal detachment, such as that associated with stage 4 ROP in which the encircling band has to be removed after several months.**

Key words: scleral buckling – silicone – cyanoacrylate – rabbit.

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The use of tissue adhesives as an alternative to sutures goes back to the mid-1950s, when the methyl 2-cyanoacrylate adhesive, Eastman 910, was first marketed for use in the field of medicine (Coover et al. 1959). Subsequent studies (Calabria et al. 1970, 1971; Spitznas et al. 1973) introduced the use of isobutyl 2-cyanoacrylate in scleral buckling surgery and in sutureless retinal reattachment as a new experimental method. The adhesive appeared to be well tolerated by ocular tissues, but in light of the short duration of the bond it produced and the migration of the encircling band observed in animals subjected to scleral buckling, both groups of investigators concluded that this glue was not suitable for use in the human eye. More recently, however, butyl 2-cyanoacrylate has been used to reinforce shallow sutures in scleral buckling procedures in eyes with staphylomas (Folk & Dreyer 1986).

The experimental evidence collected so far indicates that tissue adhesives are not reliable enough to replace scleral sutures in retinal reattachment, but the debate is still open over their use in particular cases such as scleral buckling for stage 4 retinopathy of prematurity (ROP), high myopia or scleromalacia. Moreover, in preterm babies affected by ROP the encircling band is generally removed several months after surgery to avoid the development of high myopia and erosion of the scleral wall.

We recently tested a new technique for scleral buckling in rabbits. The method is based on the use of a new octyl 2-cyanoacrylate tissue adhesive that has been approved by the Food and Drug Administration (FDA) for clinical use in the closure of skin wounds. This glue offers significant benefits over previously used cyanoacrylates in terms of both its adhesive characteristics and holding power in experimental reattachment of the extraocular muscles to the sclera (Ricci et al. 2000).

Material and Methods

Octyl 2-cyanoacrylate surgical adhesive (Dermabond®; Ethicon, Inc.) is a sterile liquid that is slightly more viscous than water. It contains a monomer preparation (octyl 2-cyanoacrylate) and the coloring agent D & C Violet no. 2. The product is supplied in the form of single-use applicators in a blister-pack. To ensure full adhesive efficacy, the tissues to be joined must be perfectly dry.

The study was conducted on 18 adult New Zealand white rabbits (2 to 3 kg).

The animals were handled according to the ARVO statement for the Use of Animals in Ophthalmic and Vision Research. Scleral buckling was performed in both eyes of each animal (total number of eyes treated: 36). Every attempt was made to maintain complete asepsis during the surgical procedures. The animals were anesthetized with an intramuscular injection of ketamine (30 mg/kg) and xylamine hydrochloride (5mg/kg), and topical 0.4% benoxinate hydrochloride was applied before surgery. One drop of mydriatic col-

lyrium was also instilled 5 minutes before treatment.

After a 360° conjunctival peritomy, the sclera was exposed and carefully dried to remove all traces of blood. The adhesive was used to attach three small squares of silicone net (4×3×0.5 mm) to the episclera, at the level of the equator, in the spaces between the extraocular muscles. A 2.5-mm-wide Silastic band was then positioned around the globe just beneath the extraocular muscles and sutured to the silicone net patches with 5–0 prolene. The free ends of the band were then overlapped 5 mm in the infero-temporal quadrant and tightened with two clamps until a scleral buckle was evident on indirect ophthalmoscopy. The ends of the band were then joined using a small amount of the adhesive, and the conjunctiva was repositioned and sutured with 8–0 vicryl. Ophthalmoscopy was performed under general anesthesia 7, 15, 30 and 60 days after surgery to assess the scleral buckle. The stability of the scleral buckling was controlled in groups of three animals anesthetized respectively on postoperative days 15, 30, 60, 90 and 180. After enucleation and fixation in formaldehyde, these eyes were studied histologically. Sections of underlying tissues to the scleral buckling (sclera, choroid and retina) were stained with hematoxylin and eosin and examined under the light microscope to evaluate local reactions.

In a separate experiment, four other rabbits were killed with an overdose of pentobarbital, and the sclera of each eye (total: 8) was exposed. The adhesive was applied to half the length (3 mm) of a Silastic strip measuring 6×3×0.5 mm and the strip attached to the sclera. After ten minutes, a 4–0 black silk suture was passed through the free end of the strip and attached to the neck of a plastic bottle (weight: 70 g) suspended in space from the head of the operating table. Water was gradually added to the bottle using a 5 cc syringe until the load was sufficient to detach the strip from the sclera. The weight of the bottle (in grams) was then recorded as an index of the strength of the bond.

Results

There were no infectious complications in any of the 36 eyes subjected to surgery. Scleral buckling was clearly observed in all indirect ophthalmoscopic controls following surgery. In 33 of the 36 eyes examined at different periods after surgery (from 15 to 180 days), the Silastic band remained in position and the small squares of silicone were firmly attached to the sclera. In the remaining 3 eyes (one examined 15 days after surgery, two examined after 45 days), the band had slipped somewhat due to detachment of one of the three patches, but in all three cases the scleral buckle was still present. In particular, in all 6 of the eyes examined six months after surgery, the buckle appeared stable with no signs of patch detachment. After enucleation, a thin, translucent fibrous capsule was evident over the silicone encircling bands. Histological examination of these eyes showed only a superficial scleral reaction represented by chronic inflammatory cells, fibroblasts and foreign body giant cells (Fig. 1). The sclera underlying the Silastic band presented an almost normal thickness.

In the 8 eyes examined post-mortem, the mean load capable of detaching the Silastic band from the sclera 10 minutes after gluing was 220±35 g.

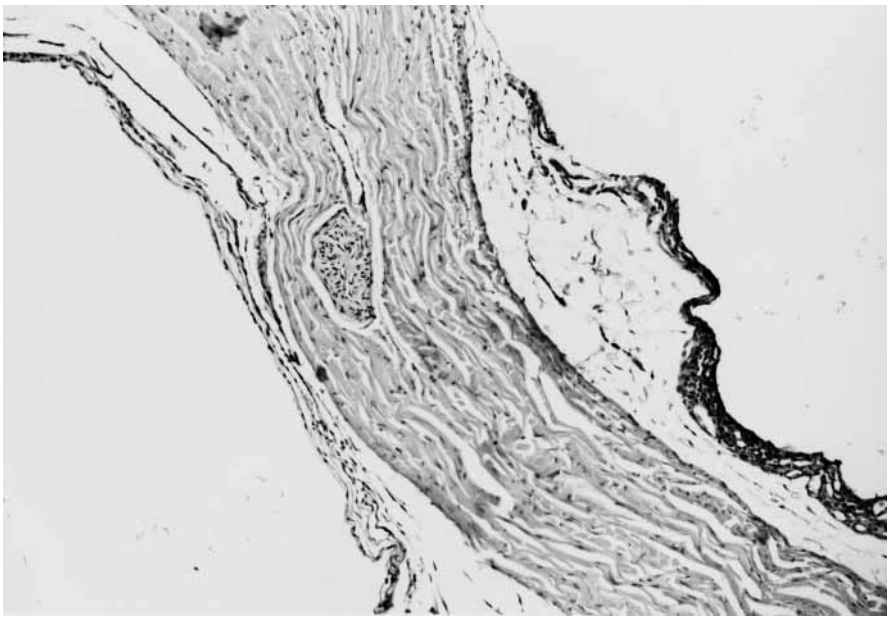

Fig. 1. Histological section of the sclera underlying the Silastic band.

Discussion

In this experiment an encircling band of silicone was placed around the equator of the globe and anchored by means of 5–0 prolene sutures that were not passed through the sclera itself, but through three tiny squares of silicone that had been glued to the sclera with octyl 2-cyanoacrylate tissue adhesive so that a silicone-silicone junction was created.

Our preliminary results indicate that a band anchored in this manner is effective up to six months after application. In three cases (one examined after 15 days, two after 45 days) the band had slipped somewhat because one of the three silicone squares had become detached from the sclera. Probably, this may have been the result of the fact that the sclera was not perfectly dry at the moment of attachment.

The adhesive we used was an octyl 2-cyanoacrylate, which is recognized to be more effective than other cyanoacrylates and also less toxic to tissues due to the presence of longer chained alkyl groups (Trott 1997). When the adhesive is applied to a completely dry surface, the surgeon has 45–60 seconds to position the tissues before polymerisation occurs; full efficacy is achieved after approximately two minutes. In addition, the adhesive forms a flexible film that does not crystallize, thus reducing the risk of local inflammation.

In the post-mortem experiments of the present study, the silicone-scleral bond was already able to withstand a mean tractional force of 220±35 grams ten minutes after gluing.

The advantage of sutureless scleral buckling is that it reduces the risk of perforation of the bulb, which is particularly significant when the sclera is extremely thin, e.g., in a preterm newborn, or in cases of high myopia and scleromalacia.

Unfortunately, the use of surgical adhesives has not won widespread acceptance mainly because the strength and durability of the bonds they produce have proved to be less than satisfactory. In fact, the cyanoacrylates used thus far in animal studies, such as butyl or isobutyl 2-cyanoacrylate (Calabria et al. 1970; Spitznas et al. 1973), have displayed signs of weakening over time.

One of the main differences between previous studies and the present one is the strength of the silicone-scleral bond we produced with octyl 2-cyanoacrylate. Ten minutes after attachment, this adhesive was already much stronger (220±35 g) than the isobutyl 2-cyanoacrylate adhesive after 24 hours (154±51.9 g) (Calabria et al. 1971). The second novelty in our technique is the silicone-silicone suture we created. The Silastic band was sutured to silicone patches that had been glued to the sclera, eliminating the need to pass the needle through the sclera itself.

If the efficacy of sutureless buckling technique we tested is confirmed in future studies, we feel that it can offer real advantages over conventional surgery, particularly in cases requiring temporary buckling, e.g., retinal detachment in preterm babies. Even if the holding power of the adhesive should decrease over time due to biodegradation, a bond that lasts six months (which is the duration we observed in our experimental cases) would be sufficient in these patients since the Silastic band has to be removed a few months after surgery.

Naturally, testing should be also performed to evaluate the long term performance of the silicone-scleral bond (i.e., more than a year after attachment), although there are a number of difficulties involved in maintaining experimental animals for periods of this length. In any case, it is clear that additional animal experiments will be necessary before this technique can be used in humans.

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