

Sutureless Strabismus Surgery: An Animal Study

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Abstract

Background: Tissue adhesives have been used in strabismus surgery either for muscle recession or Faden operation as muscle weakening operations. For the first time, this study investigates the use of tissue adhesives for strengthening an extraocular muscle.

Methods: The tissue adhesive selected was the Isoamyl-2-Cyanoacrylate sterile adhesive. Thirty superior recti muscles were subjected to a recession of 5 mm and thirty medial recti muscles were subjected to a 10 mm plication. All were applied in an in-vivo procedure in 15 New Zealand white male rabbits. We operated on both eyes of each rabbit. The surgical procedure included recession of both superior recti and plication of both medial recti. We used absorbable 6/0 polyglactin sutures for the plication and recession in one eye and the tissue adhesive for plication and recession in the other eye. The muscles were processed for light and electron microscopic examinations.

Results: Sutures and cyanoacrylate produced comparable expected measurements in both recession and plication. The inflammation produced by the tissue adhesive was less than that produced by sutures either in recession or plication groups up to the 4th week postoperatively evident by electron microscopy.

Conclusion: The study proved that the use of iso-amyl-2 cyanoacrylate is an effective alternative in creating a stable plication that can be used to strengthen an extraocular muscle and produces less inflammatory reaction than sutures.

Keywords: *Extraocular Muscles; Recession; Resection; Sutureless; Tissue Adhesive; Electron Microscopy*

Introduction

Strabismus surgery employs the use of sutures either to recess or resect an extraocular muscle. Complications related to this procedure have been reported and scleral perforation is among the most dangerous of these complications [1]. To avoid such complications, tissue adhesives have been investigated as an alternative method in muscle surgery [2].

Tissue adhesives have been used in muscle recession [3] or Faden operation [4], both considered as muscle weakening operations. However, no study applied tissue adhesive to strengthen an extraocular muscle.

A variety of tissue adhesives have been used, each tissue adhesive has its advantages and complications. A perfect tissue adhesive should induce minimal inflammatory reaction, have minimal toxicity, create the desired amount of recession, myopexy or plication, and yield sufficient tensile strength. Extensive revision of all previous reports suggested that the cyanoacrylate group tissue adhesives are the best compared to other types [3-7].

Aim of the Study

The aim of this study is to investigate the use of tissue adhesives for strengthening an extraocular muscle, an endeavor that has not been described in the literature before. The study protocol was presented in 2009 in WCPOS and the preliminary results were included in ECronicon in 2015 [8].

Materials and Methods

The study was conducted in the research institute of ophthalmology, Cairo - Egypt after approval of the institute's research ethics committee. The study followed the tenets of The Declaration of Helsinki.

Isoamyl-2-Cyanoacrylate sterile adhesive was used in all experimental eyes. The agent, (AMCRYL - ate[®]), is provided by Concord Drug Ltd- India in ampoules containing 0.5 ml Isoamyl-2-Cyanoacrylate.

The study was conducted on the superior and medial rectus muscles of the eyes of 15 New Zealand white male rabbits (*Oryctolagus cuniculus*) ranging in weight from 1300 - 2400 grams.

We operated on both eyes of each rabbit and a total of sixty eyes were included in the in-vivo procedure. We used absorbable 6/0 polyglactin sutures for the recession of the superior rectus and plication of the medial rectus in one eye and the tissue adhesive for the recession of the superior rectus and plication of the medial rectus in the other eye. A total of thirty superior rectus muscles were recessed 5 mm from the muscle tendon insertion and thirty medial rectus muscles were plicated 10 mm at the muscle insertion.

The study eyes were divided into 4 groups:

1. **Group 1:** 15 superior rectus muscles were recessed using absorbable 6/0 polyglactin sutures (Control group).
2. **Group 2:** 15 medial rectus muscles were plicated using absorbable 6/0 polyglactin sutures (Control group).
3. **Group 3:** 15 superior rectus muscles were recessed using Isoamyl-2-cyanoacrylate sterile adhesive.
4. **Group 4:** 15 medial rectus muscles were plicated using Isoamyl-2-cyanoacrylate sterile adhesive.

Surgical technique

A combination of 5 mg/kg Hydralazine and 35 mg/kg ketamine was administered intramuscularly for anesthesia. Immediately before surgery, a topical anesthetic (proxy-metacaine 0.5%) was used. The muscles were approached through limbal conjunctival incisions.

Group 1: The superior rectus muscles were recessed for 5 mm from the muscle tendon insertion using absorbable 6/0 double-armed polyglactin (Vicryl) sutures.

Group 2: The medial rectus muscles were plicated for 10mm at the insertion sites using absorbable 6/0 double-armed polyglactin (Vicryl) sutures.

Group 3: The superior rectus muscle was gently clamped with fine hemostats 6 to 7 mm from the insertion site. The sites of recession were marked on the sclera on either sides of the muscle. The muscle was severed at the insertion using Westcott scissors and was fixed with a fixation forceps, the hemostat was removed, the sclera was dried with a cotton tip at the sites of recession and few minims of the adhesive were injected using a 25 gauge cannula. The muscle was immediately applied to the sclera at the desired site for 30 seconds until attachments occurred.

Group 4: The medial rectus muscle was hooked. The muscle hooks were elevated and the amount of plications (10 mm) were marked by using a Castroviejo caliper adjusted at 5 mm. the measurements were done starting from the insertion site to the elevated hook causing tenting of the muscle. Few minims of the tissue adhesive were injected just behind the muscle insertion and the two portions of the tinted muscle were approximated to each other using fine hemostat for 30 seconds until attachments occurred and the plications were achieved.

In all groups the conjunctiva was closed with interrupted 6/0 polyglactin Sutures and an ophthalmic ointment containing tobramycin and dexamethasone was applied to the superior conjunctival fornix.

The rabbits were sacrificed after 7, 14 and 30 days. An intracardiac pentobarbital sodium injection was used after anesthesia was induced.

The distance of recession was measured with the Castroviejo caliper (from original insertion to both margins of the superior rectus muscle). The eyes were enucleated with special care to the anterior parts of the extraocular muscles attached to the sclera. The sites of muscle insertion were excised and tissue obtained was immediately immersed in 4% glutaraldehyde, post-fixed in osmic acid and processed for light and electron microscopic examinations.

Results

All groups presented measurements close to the expected distance of 5 mm for recession and 10 mm for plication. Failure of the tissue adhesive to maintain muscle plication did not occur in any of the test muscles up to the 4th week postoperatively.

Histological examination showed a chronic inflammatory reaction of the foreign body type with similar intensity and the progress of healing process was the same in all groups.

The reaction developed around the scleral fixation sutures or adhesive and consisted of histiocytes, some of them were multi nucleated lymphocytes, plasma cells and polymorphonuclear leukocytes.

Prominent collagen formation was noticed in all groups.

In case of recession with polyglactin sutures, light and electron microscopy revealed by the 4th week diffuse fibrillary atrophy in the form of decreased diameter together with heavy infiltrations with macrophages and fibroblasts.

Ultra-structurally there were alterations of muscle fibers with atrophy and angulations, with distortion of the myofibrillar matrix and disappearance or alteration of the z bands of the muscle fibers (Figure 1).

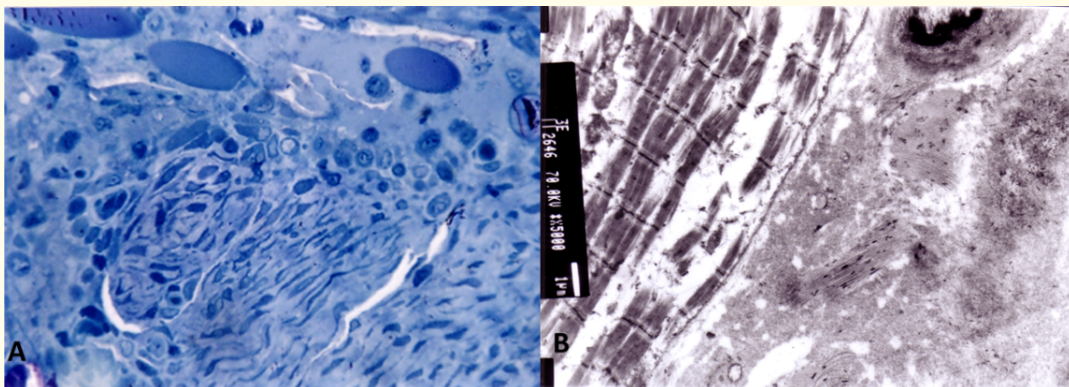


Figure 1: Fourth week postoperative images of: (A); light microscopy (Toluidine blue - magnification x 40) and (b); transmission electron microscopy (magnification x 5000), of tissue excised at insertion site in a rabbit eye where the muscle was recessed using Vicryl sutures, showing diffuse atrophy, decreased fibrillar diameter, with heavy infiltrations of macrophages and fibroblasts. Note the alteration of muscle fibers with atrophy and angulations, distortion of the myofibrillar matrix and disappearance or alteration of the z bands of the muscle fibers.

When the tissue adhesive was used for recession all previous histologic changes were less and the muscle tissue appeared much intact with electron microscopy by the 4th postoperative week (Figure 2).

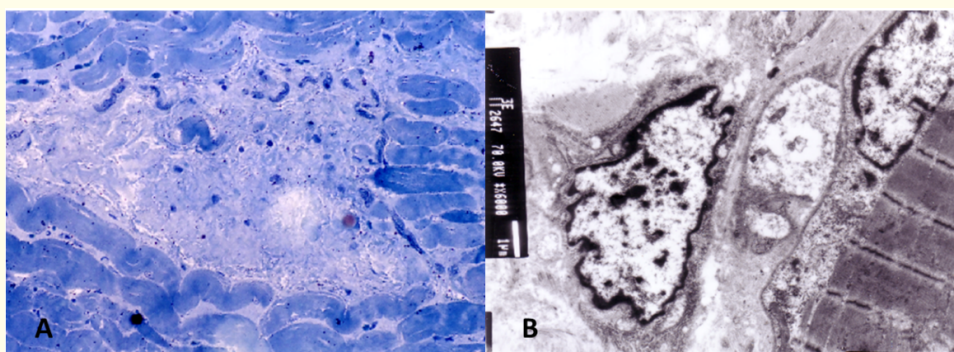


Figure 2: Fourth week postoperatively, recession using tissue adhesive: (A); light microscopy (Toluidine blue - magnification x 40) and (b); transmission electron microscopy (magnification x 6000), of tissue excised at insertion site in a rabbit eye where the muscle was recessed using tissue adhesive. All previous histologic changes were less than those shown in figure 1 and the muscle tissue appeared much intact with electron microscopy by the 4th postoperative week.

In case of plication with polyglactin sutures, by the 4th week postoperatively there was marked muscle hyalinization and mitochondria showed marked increase in size mainly in the peri-nuclear area (Figure 3).

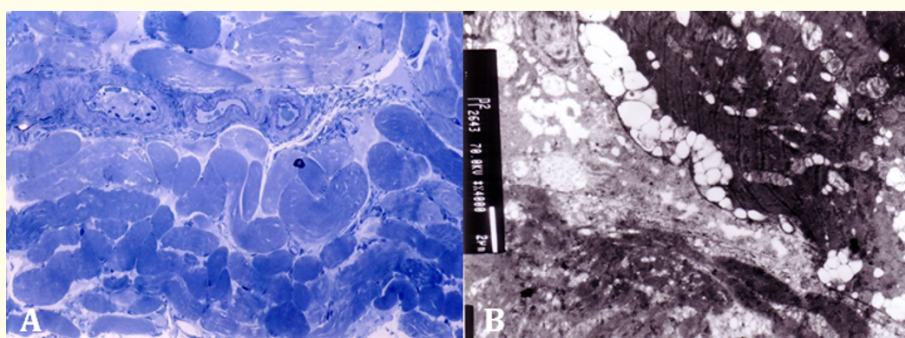


Figure 3: Fourth week postoperatively, plication using sutures: (A); light microscopy (Toluidine blue - magnification x 40) and (b); transmission electron microscopy (magnification x 4000), of tissue excised at plication site in a rabbit eye where the muscle was plicated using Vicryl sutures, were marked muscle hyalinization and mitochondria showed marked increase in size mainly in the peri-nuclear area.

When plication was done with the tissue adhesive, much less muscle degeneration and hyalinization were noticed by the 4th week postoperatively. Macrophages engulfing tissue adhesive granules were also noticed (Figure 4).

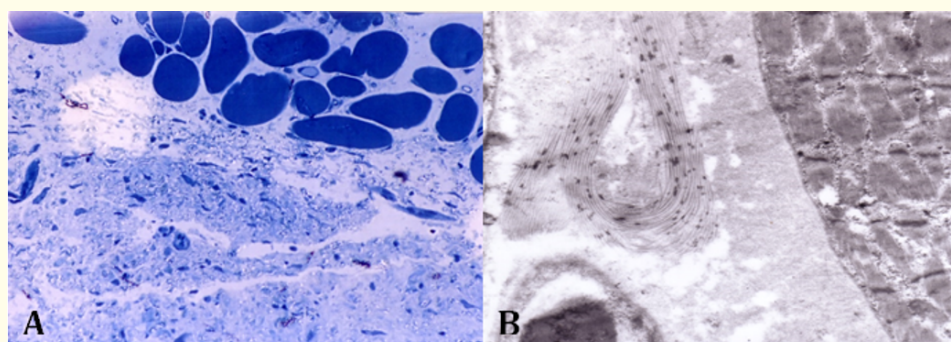


Figure 4: urth week postoperatively, plication by tissue adhesive: (A); light microscopy (Toluidine blue - magnification x 40) and (b); transmission electron microscopy (magnification x 12000), of tissue excised at plication site in a rabbit eye where the muscle was plicated using tissue adhesive, showing less muscle degeneration and hyalinization, with macrophages engulfing tissue adhesive granules.

Discussion

The rationale behind replacing sutures in strabismus surgery was to avoid intraoperative and postoperative complications unique to the use of sutures i.e. scleral perforation, vitreous hemorrhage, and retinal detachment.

Tissue adhesives have been used in muscle recession [3] or Faden operation [4], both considered as muscle weakening operations. However, no study applied tissue adhesive to strengthen an extraocular muscle. To our knowledge, the current study is the first to study the efficacy of using iso-amyl-2 cyanoacrylate tissue adhesive in muscle plication.

Our decision to use iso-amyl-2 cyanoacrylate was based upon an extensive comparative study of previous experiences. We selected the tissue adhesive that will produce the least toxic reaction. In addition, it should result in the desired amount of recession, plication and myopexy with the creation of strong adhesive force that will resist separation.

In the current study, all groups presented measurements close to the expected distance of 5 mm for recession and 10 mm for plication. We did not encounter failure of the tissue adhesive to maintain muscle plication in any of the test muscles up to the 4th week postoperatively.

Our observation that sutures and cyanoacrylate produced comparable expected measurements in both recession and plication is in accordance with other published results where sutures and cyanoacrylate were used in Faden operation [4].

The inflammation produced by the tissue adhesive was less than that produced by sutures either in recession or plication groups up to the 4th week postoperatively evident by electron microscopy.

Conclusion

The study proved that the use of iso-amyl-2 cyanoacrylate is an effective alternative in creating a stable plication that can be used to strengthen an extraocular muscle and produces less inflammatory reaction than sutures.

Conflict of Interest

No conflict of interest exists for any of the authors.

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