Optimization of Fibrin Glue Spray Systems for Ophthalmic Surgery

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Purpose: To optimize fibrin glue (FG) spray for ophthalmic surgery using two spray applicators, EasySpray and DuploSpray systems, by varying the distance from point of application and the pressure/flow rate, and to compare the adhesive strength of sutured and sutureless (FG sprayed) conjunctival graft surgery in a rabbit model.

Methods: FG was sprayed on a 0.2 mm-thick sheet of paper using EasySpray by variously combining application distances of 2.5, 5, 7.5, and 10 cm with pressures of 10, 15, and 20 psi. DuploSpray was used at the same distances but with varying flow rates of 1 and 2 L/min. Subsequently, FG was sprayed on porcine corneas and FG thickness was analyzed by histology. In addition, adhesive strength of the conjunctival graft (0.5 × 0.5 cm) attached to the rabbit cornea by sutured and sutureless surgery (FG spray) was compared using a tension meter.

Results: Histology measurements revealed that the FG thickness decreased with increases in distance and pressure of spray using the EasySpray applicator on paper and porcine corneal sections. The adhesive strength of the sutured conjunctival graft (41 ± 4.85 [kilopascal] KPa) was found to be higher than the graft attached by spraying (10 ± 2.3 KPa) and the sequential addition of FG (6 ± 0.714 KPa).

Conclusions: The EasySpray applicator formed a uniform spread of FG at a distance-pressure combination of 5 cm and 20 psi. The conjunctival graft attached with sutures had higher adhesive strength compared with grafts glued with a spray applicator. Although the adhesive strength of FG applied through the applicator was similar to the drop-wise sequential technique, the former was more cost effective because more samples could be sprayed compared with the sequential manual technique.

Translational Relevance: The standardization of the spray system for the application of FG in ophthalmology will provide an economical method for delivering consistent healing results after surgery.

Introduction

Tissue adhesives have been used in ophthalmic surgery since the early 20th century.^{1,2} They are broadly divided into two classes: synthetic and biological adhesives. Cyanoacrylate adhesives are one of the most common synthetic adhesives used in ocular surgery since 1963.³ They have been used extensively for wound closure during cataract surgery,⁴ scleral buckling surgery,⁵ and retinal detachment surgery,⁶ but are not biointegratable with

tissues. Therefore, these adhesives usually can be applied only on the surface of tissues to be glued and in situations where the glue compound will ultimately slough off or be removed after healing has occurred. Biological sealants such as fibrin glue (FG) are therefore partially replacing the use of these synthetic glues due to their ability to be used in between tissue layers, with excellent biodegradability, biocompatibility, and transparency, and their rapid setting time.^{2,7} In addition, biological adhesives induce minimal inflammation because they are obtained from blood-

derived components and their action mimics the natural coagulation pathway.⁸ FG has wide applications in ophthalmology for treating leaking blebs,⁹ corneal perforations, and ulcers,¹⁰ for conjunctival grafts for pterygium surgery,^{11–13} for lamellar keratoplasty,^{14,15} for strabismus surgery,¹⁶ and as a suture substitute during glaucoma drainage surgery.¹⁷ The authors recently reported the use of intracameral FG during deep anterior lamellar keratoplasty (DALK) with macroporations.¹⁸

Fibrin glue is made of two main components: fibrinogen and thrombin. It is usually applied manually by sequential mixing to cover the wound area, or by using a double injector system whereby the two components are admixed upon injection through a single cannula opening directly applied to the gluing site.¹⁹ The application of FG onto tissues has evolved from a manual sequential application technique to the use of applicator systems designed specifically for different organ or tissue types and surface area of the surgical site.^{14,20} Manual or sequential mixing of components, dispensing one component on the tissue surface and the other on the place of attachment, usually produces a nonhomogenous and loose clot.²¹ Hence, the evolution of applicator systems has enhanced the use of FG in surgical interventions because it controls the amount of fibrin glue ejected and produces a homogenous layer upon spraying.²²

In this study, Tisseel (Baxter Healthcare Corporation, Deerfield, IL) FG spray delivery was evaluated and optimized using the EasySpray (Baxter Healthcare) delivery system and the DuploSpray (Baxter Healthcare) applicator system, adapting its use for ocular surgery, specifically conjunctival flap surgery for pterygium. The delivery conditions were optimized for the fibrin sealant so as to deliver a layer of fibrin glue that was of predictable and uniform thickness. There is no literature available on the application of glue using spray systems in ophthalmic surgery. A comparison was made of the adhesive strength of drop-wise unmixed sequential application of FG and spray application with that of conventional sutures in an *in vivo* rabbit model of conjunctival autograft surgery.

Materials and Methods

Animals

The animal experiments were followed according to rules and regulations of the Association for

Research in Vision and Ophthalmology Statement for Use of Animals in Ophthalmic Vision and Research, and approved by the institutional review board and ethics committees of the Singapore National Eye Centre and Singapore Eye Research Institute. Five female New Zealand white rabbits weighing 2.5 to 3.0 kg were used for adhesion testing experimentation. Ten eyes were divided into three groups: five eyes yielding 10 conjunctival grafts were used for the conjunctival graft suture adhesion experiment; five eyes yielding another 10 conjunctival grafts were further divided; five conjunctival grafts for the FG spray adhesion experiments using the EasySpray (Baxter Healthcare) applicator and five conjunctival grafts for the drop-wise addition of FG adhesion experiment.

Preparation of Tisseel Fibrin Tissue Glue

The FG was reconstituted according to the manufacturer's protocol (Tisseel VH Fibrin Sealant). The Tisseel (Baxter Healthcare) kit contained the sealer protein concentrate (fibrinogen) and the sealant (thrombin). The thrombin concentration determines the setting time of the fibrin sealant from 30 seconds (rapid setting) to several minutes (slow setting). Aprotinin (fibrinolysis inhibitor) was added to the sealer protein concentrate, and calcium chloride (CaCl₂) solution was reconstituted with thrombin. Twenty microliters of 0.5% Trypan blue were added to 2 mL of thrombin-CaCl₂ mixture to allow visualization of the spread of FG after spraying. The reconstitution procedure was carried out in a patented fibrinotherm-heating device (Baxter Healthcare) that maintains an optimal physiological temperature of 37°C with constant stirring. The two final components were drawn in their respective syringes. Care was taken to avoid formation of air bubbles. The syringes were connected to a common Duploject plunger for simultaneous application of glue components. A spray head was fastened to the plunger, which regulated the flow of FG.

Applicator Systems

For spraying the FG, the EasySpray (Baxter Healthcare) system and DuploSpray (Baxter Healthcare) applicator were used (Fig. 1). The syringe containing each component of Tisseel (Baxter Healthcare) glue was attached to the Duploject syringe holder. The Duploject plunger was connected to the EasySpray (Baxter Healthcare) system or DuploSpray (Baxter Healthcare) system. The EasySpray (Baxter

Figure 1. Experimental set up of EasySpray applicator systems (A) and DuploSpray applicator systems (B).

Healthcare) system was operated using carbon dioxide (CO₂) maintained at a controlled pressure range of 10 to 20 psi. Occluding the clip center with the operators thumb activated the spray of fibrin sealant (Fig. 1A). The arrangement of the DuploSpray (Baxter Healthcare) applicator system was similar to the EasySpray (Baxter Healthcare) system except for the difference in the spray head or the nozzle used for application. The DuploSpray (Baxter Healthcare) system used a long shaft with dual lumen tubing, each carrying separate components of Tisseel (Baxter Healthcare) tissue glue attached to the spray head of the Duploject syringe holder (Fig. 1B). The flow rate of the CO₂ for the DuploSpray (Baxter Healthcare) system can be varied between 1 to 2 L/min using the regulator.

Optimization of the Fibrin Glue Spray

The optimization experiment involved simultaneous variation in the pressure or flow rate and in distance of application of FG with individual spray systems. Spray distances of 2.5, 5, 7.5, and 10 cm were used for both applicator systems. Pressure variations of 10, 15, and 20 psi, and flow rates of 1 and 2 L/min were tried in the EasySpray (Baxter Healthcare) and DuploSpray (Baxter Healthcare) systems, respectively. Slow-setting FG was sprayed with the above mentioned combinations of distances and pressures/flow rates on an A4-sized sheet of paper with a thickness of 0.183 ± 0.002 mm. Following spray application, the glue was deposited as blue spray zones, which appeared as circles of various diameters depending on the pressure and distance from the sheet of paper. The sprayed zones on the paper sections (approximately 3 to 4 cm in diameter) were cut in half and embedded in tissue freezing mixture (Leica Microsystems [SEA] Pte Ltd, Singapore) for further

analysis. For each distance and pressure setting, three spray zones were analyzed to assess the thickness of the spray on the paper. Forty-micron thick sections from the central and the peripheral regions of the spray zones were cut using a cryostat (Carl Zeiss MicroImaging GmbH, Jena, Germany) and examined for the difference in the thickness of FG for each tested combination using an Axioplan, Zeiss Light Microscope (Carl Zeiss MicroImaging) under bright field mode. For each combination of distance and pressure, five readings of thickness measurements at the central and peripheral regions of the spray zones were taken.

Ex Vivo Application of Fibrin Glue

Based on preliminary results described above with various combinations of distance and pressure or flow rate, fresh whole porcine eyes were used within 2 to 3 hours of enucleation and placed on a holder. They were then sprayed using the EasySpray (Baxter Healthcare) applicator at distances of 5 and 7.5 cm at a pressure of 20 psi. This was done to ensure the repeatability of using the applicator systems in animal tissue. The cornea was harvested and embedded in optimal cutting medium (OCT). Samples were stored at -70°C until analyzed by histology.

Light Microscopy

Eight micrometer-thin sections of frozen porcine corneas sprayed with FG were cut using cryostat and analyzed by hematoxylin and eosin (H&E) staining. Briefly, the glass slides containing cornea sections were air dried for 10 to 15 minutes and rehydrated with 95% ethanol for 5 minutes. The slides were then washed prior to hematoxylin staining for 1 minute followed by treating with Scott's tap water for 5 minutes, which intensified the nucleus staining. The slides were counter stained with Eosin for 2 minutes following washing in tap water. Series of dehydration with 95% and 100% ethanol were carried out for 5 minutes each. The sections were mounted after two changes of xylene for 2 minutes each and examined using Axioplan, Zeiss Light Microscope (Carl Zeiss MicroImaging) under bright field mode.

Adhesion Strength Testing

In order to assess the in vivo efficacy of the FG spray, a rabbit model was used for pterygium surgery. For preparation of rabbit conjunctival grafts, a 10/0-loop suture was passed beneath each eyelid separately and clamped to a mosquito clamp for firm attach-

ment. An operating microscope was used throughout the surgical procedures. The rabbits were anaesthetized intramuscularly with an injection of ketamine (40 mg/kg), xylazine (4 mg/kg), and a few drops of topical xylocaine before surgery. Balanced salt solution (BSS) was initially injected subconjunctivally to balloon out the conjunctival membrane using a 25-g needle for easy dissection of the graft. A rectangular portion of conjunctival tissue measuring 1×0.5 cm was excised from the superior bulbar conjunctiva and split into two equal halves of 0.5×0.5 cm portions. Any underlying Tenon's capsule that was inadvertently removed with the conjunctival tissue was carefully dissected off the posterior surface of the graft using surgical scissors to obtain a pure conjunctival graft. Because the rabbit has an excessive amount of Tenon's capsule, the conjunctival graft was adhered to the corneal surface instead of bare sclera to assess the adhesive strength of the different methods of attachment. The corneal epithelium was first removed with a #64 Beaver blade before suturing or gluing (FG) the conjunctival graft to aid in firm attachment onto the corneal surface.

The dissected conjunctival grafts were divided into three groups for study: (1) a sutured group, where the four corners of conjunctival graft was sutured on to the cornea with 10/0 nylon sutures. A loop of 6/0 nylon suture was passed under the graft to attach to the tension meter for adhesion testing of the (2) FG spray group, where the excised conjunctival grafts were sprayed with FG on their stromal surfaces using EasySpray (Baxter Healthcare) applicator at a distance of 5 cm with 20 psi pressure (optimized earlier). Slow-setting Tisseel (Baxter Healthcare) mixture (1 minute setting time) was used for this experiment so that manipulation of the graft could be done before the glue polymerized completely. The grafts were then inverted and placed on the corneal surface. A loop of 6/0 black silk was preplaced on the corneal surface prior to inversion of the graft (3) FG drop-wise sequential application, where following excision of the conjunctival graft, FG components were applied in a sequential manner with the thrombin (thick component) to the stromal surface of the conjunctival graft and the fibrinogen (thin component) to the corneal surface. The graft was then inverted, stromal surface down, onto the corneal surface. A loop of 6/0 black silk was preplaced on the corneal surface prior to inversion of the graft. The adhesive strength of the conjunctival grafts was tested 10 to 15 minutes after suturing or FG application. A knot was tied in the 6/0 black silk loop at a fixed

distance range of 3.5 to 4.5 cm from the hook of the tension meter gauge (Scientific Instruments & Services Pte Ltd, Singapore) with the speed of pulling maintained at 20 mm/min throughout the experiment. The conjunctival grafts were positioned perpendicular to the tension meter during pulling and the strength of the graft adhesion was calculated based on the force required to dislodge the graft completely. The force recorded on the gauge was further analyzed using Nexygen TCD series software (Scientific Instruments & Services Pte Ltd).

Statistical Analysis

The statistical analysis was done using Prism 5 software (GraphPad Software, La Jolla, CA). All the data were tested for normality using Kolmogorov-Smirnov test. A one-way ANOVA with Newman-Keuls multiple comparison post-hoc test was performed. The level of significance was calculated with $P < 0.05$. The statistical data was reported as mean $\pm$ SEM.

Results

Applicator Systems

In preliminary experiments, we found the EasySpray (Baxter Healthcare) applicator (Fig. 1A) was found to be better in terms of uniform spray thickness obtained compared with the DuploSpray (Baxter Healthcare) system. It was observed that the FG polymerized easily in the long shaft of the DuploSpray (Baxter Healthcare) nozzle (Fig. 1B) and that the nozzle has to be changed more often due to blockage. The formation of air bubbles and resultant blockage in the flow of FG was a major drawback with the DuploSpray (Baxter Healthcare) system.

Optimization of the Fibrin Glue Spray

Several optimization experiments were performed to standardize the distance and pressure/flow rate required to obtain an even spread of FG using the EasySpray (Baxter Healthcare) and DuploSpray (Baxter Healthcare) systems. The thickness of FG sprayed using the applicators was analyzed by histology (Fig. 2A). The diameter of the EasySpray (Baxter Healthcare) spray zones increased with consistent distance and pressure of application. On varying the pressure of flow from 10 to 15 psi, the central thickness of FG decreased from 33 to 29 μ m at 2.5 cm ($P < 0.01$) and 32 to 23 μ m at 5 cm ($P <$

Figure 2. Histology of paper sections (A) and porcine corneal sections (B) after spraying with fibrin glue using EasySpray applicator. Black arrow represents the fibrin glue layer.

0.001). However, at distances of 7.5 and 10 cm, the thickness increased on varying the pressure from 10 to 15 psi ($P < 0.001$). When the pressure was increased from 15 to 20 psi, the central thickness of FG did not show a significant difference at 5 cm. However, there

was a significant increase at 7.5 cm, from 22 to 17 μm ($P < 0.01$), when the pressure was increased from 15 to 20 psi. The central thickness increased at 2.5 cm from 28 to 45 μm ($P < 0.001$), and at 10 cm decreased from 20 to 10 μm ($P < 0.001$) when the pressure was increased from 15 to 20 psi. On varying the distance from 2.5 to 10 cm, the central thickness of FG decreased significantly from 33 to 13 μm at a pressure of 10 psi ($P < 0.001$), from 28 to 20 μm at 15 psi ($P < 0.001$), and from 44 to 9 μm at 20 psi ($P < 0.001$). At the periphery, the variations of thickness with distance and pressure were similar to that at the central regions (Figs. 3A and 3B).

In the DuploSpray (Baxter Healthcare) applicator group, the diameter of the spray zones varied independently with increases in distance and flow rate. The thickness of FG sprayed using the DuploSpray (Baxter Healthcare) applicator at the central and peripheral regions (Figs. 3C and 3D) varied inconsistently with changes in distance and pressure. On varying the flow rate from 1 to 2 L/min, the

Figure 3. Average thickness of fibrin glue at the central (A) and peripheral sections (B) using EasySpray applicator at distances of 2.5, 5, 7.5, and 10 cm, and varying pressures of 10, 15, and 20 psi and average thickness of fibrin glue at the central (C) and peripheral sections (D) using DuploSpray applicator at distances of 2.5, 5, 7.5, and 10 cm, and varying flow rates of 1 and 2 L/min. Error bars represent SEM. * represents $P < 0.05$, ** represents $P < 0.01$, and *** represents $P < 0.001$.

thickness of FG at the center decreased from 39 to 16 μm at a distance of 5 cm ($P < 0.001$), and from 76 to 22 μm at 7.5 cm ($P < 0.001$). However, there was no significant change in thickness at a distance of 2.5 cm at flow rates of both 1 and 2 L/min. There was a significant decrease in the thickness of FG at the periphery when the flow rate was increased from 1 to 2 L/min: 54 to 22 μm at 5 cm distance ($P < 0.001$) and 122 to 28 μm at 7.5 cm distance ($P < 0.001$). However, there was no significant change at the distances of 2.5 and 10 cm for both the flow rates.

Histology of Porcine Cornea

The standardized combinations of distances 5 cm and 7.5 cm with 20 psi pressure using the EasySpray (Baxter Healthcare) applicator device on paper sections were used for spraying porcine corneas (Fig. 2B). There was a significant decrease of central thickness of FG from 40 μm at 5 cm distance to 23 μm

at 7.5 cm distance ($P < 0.001$) (data not shown). At the peripheral sections, the thickness decreased from 63 μm at 5 cm distance to 42 μm at distance of 7.5 cm ($P < 0.01$) (data not shown).

Adhesion Strength Measurement

The experimental setup for the measurement of adhesion strength in the fibrin glue applied on corneas for conjunctival grafts is depicted in Figure 4. The force required to dislodge the sutured conjunctival graft (1.02 N) was significantly higher compared with the FG sprayed using the EasySpray (Baxter Healthcare) applicator (0.265 N, $P < 0.001$) and also with drop-wise application (0.149 N, $P < 0.001$). However, no significant difference was found between the sprayed and manual drop-wise applications of FG. The adhesive strength was calculated in terms of force required to dislodge the graft over the measured surface area of the conjunctival graft. Adhesive

Figure 4. Experimental setup for the adhesion strength measurements of the fibrin glue applied to the conjunctival grafts. The conjunctival graft was sutured onto cornea (A), the conjunctival graft was attached with fibrin glue sprayed with EasySpray applicator (B), dislodgement of the graft was attached with fibrin glue during the adhesion strength test (C), and adhesion strength was tested using tension meter gauge (D).

strength for the sutured group (41 ± 4.85 KPa) was found to be significantly higher than the group sprayed with FG (10 ± 2.3 KPa, $P < 0.001$) and the group with the drop-wise addition of FG (6 ± 0.714 KPa, $P < 0.001$) (Fig. 5). However, no significant difference was found between the group sprayed with FG and that added drop-wise manually.

Discussion

In this study, the delivery of FG was optimized using commercially available spray applicator systems, the EasySpray (Baxter Healthcare) and DuploSpray (Baxter Healthcare) applicators. These spray applicators have a broad range of clinical applications in abdominal laparoscopic surgeries for treating inguinal hernia,²³ hepatic and splenic trauma, peptic ulcers,²⁷ and also for reducing hemorrhage during cardiac surgeries.²⁸ However, they have not been used in ophthalmic surgery, and it was hypothesized that they would have utility, in conjunctival autograft surgery for pterygium as well as for other types of surgery such as lamellar corneal transplantation procedures, in achieving uniform glue distribution of an appropriate thickness. In the current study, it was found that the EasySpray (Baxter Healthcare) double-headed plunger system was better than the long-shaft DuploSpray (Baxter Healthcare) system in terms of uniform delivery of FG and ease of handling. Also, the distance of application and pressure/flow rate variations were optimized with the EasySpray (Baxter Healthcare) and DuploSpray (Baxter Healthcare) applicator systems providing useful information for delivery of a controlled amount of FG during surgical interventions thereby reducing wastage. Finally, the efficacy and adhesion strength of the FG were analyzed using an in vivo rabbit model of pterygium surgery where it was found that the EasySpray (Baxter Healthcare) applicator provided equivalent adhesion to the conjunctival graft compared with the manual drop-wise application technique routinely used in ophthalmic surgery.

Several clinical studies revealed a wide spectrum of applications for fibrin sealant in ophthalmology due to its potential uses as a haemostatic agent, adhesive, and tissue sealant.^{24–26} However, surgeons have found manual mixing of FG components to be time-consuming and the mixture not to be homogenous, which can lead to a decrease in its adhesive strength.^{20–25} This method only allows at most 2 to 3 patients to be treated using a 2-mL syringe of FG.

Figure 5. Comparison of adhesion strength of conjunctival graft attached with sutures, fibrin glue delivered using spray system, and fibrin glue added through drop-wise application. Error bars represent SEM. *** represents significant difference between the groups of study at $P < 0.001$.

The use of an applicator system for ophthalmic surgery will allow a more homogenous layer of fibrin glue to be deposited and with potentially less wastage. The thickness of FG also influences the wound healing property of the tissue under adhesion.²² Hence, optimizing the applicator parameters was thought to be extremely important because the thickness of glue applied would affect the natural healing process.²² The EasySpray (Baxter Healthcare) applicator provided a uniform spray thickness of the FG. On the contrary, the thickness of FG sprayed using the DuploSpray (Baxter Healthcare) system was found to be extremely variable and independent of distance, pressure, or flow rate. Moreover, the presence of a long shaft in the DuploSpray (Baxter Healthcare) system resulted in glue polymerization at the nozzle tip leading to clogging, that subsequently caused formation of air bubbles. The glue components that accumulated at the periphery of the sections due to the clogging of the nozzle tip led to erratic thickness variations observed. However, there was minimal wastage of fibrin glue when applied using the EasySpray (Baxter Healthcare) applicator because approximately six to eight spray zones at a distance of 5 and 7.5 cm at a pressure of 20 psi from a 2-mL vial of fibrin glue can be sprayed.

The distance of the point of FG application from the surgical site and the pressure of delivery control-

ling the spray were found to determine the uniformity of the spray application. The FG delivery at a pressure of 20 psi from a distance between 5 or 7.5 cm was found to be accurate in forming FG spray zones of 2 to 3 cm in diameter and 17 to 22 μm thickness at the center. The increase in distance and pressure caused a reduction in thickness of FG sprayed only at distances of 5 and 7.5 cm while the other combinations showed erratic thickness values. Also, the uniformity in thickness of the FG spray was absent in the peripheral sections of the spray zones of the above-mentioned combinations, which may be attributed to the pressure of the spray causing the unpolymerized glue components to spread out centrifugally resulting in a thicker layer of glue at the periphery.

In the present study, the *in vivo* adhesion strength of FG (EasySpray [Baxter Healthcare] applicator versus drop-wise application technique) was measured using conjunctival grafts in a rabbit model of pterygium surgery compared with conventional sutures. The adhesive strength of FG applied using the spray applicator system and manual drop-wise application was also compared. Other parameters such as distance and speed of pulling, fibrin glue composition, and surface area of the conjunctival graft were kept constant throughout the experiment. Previous studies on skin grafts glued together with FG made from pooled human blood plasma have shown that the tensile strength of the adhesion depends on the fibrinogen composition, reaction time, and speed applied to pull the grafts.²⁶ Clinical studies comparing sutures with FG in pterygium surgery show that FG is effective in terms of graft stability, reduction in operating time, and recurrence rates when compared with sutures.^{11–13} Although several studies comparing the efficacy of fibrin glue and sutures on conjunctival graft surgery are reported,^{11–13,29} there has been no previous literature comparing the adhesive strength of the two techniques.

One of the limitations of the EasySpray (Baxter Healthcare) system used in this study was the use of digital pressure to depress the plunger to deliver the preferred amount of FG. This is a potential source of wastage because inadvertent excess pressure will deliver more FG glue. However, approximately 6 to 8 applications from a 2-mL vial of fibrin glue using applicators were applied as compared with manual drop-wise application, which can probably be used only in two patients. Another limitation was the adhesion strength between sutures and FG was not an exact model of pterygium surgery due to the presence

of excessive underlying Tenon's capsule in the rabbit. The primary aim was to compare the adhesive forces of different surgical techniques—suture versus FG, so the conjunctival graft was placed on scrapped rabbit cornea to provide an adequate model for the purpose of comparison. This might differ in its adhesive behavior when placed over the sclera in pterygium surgery.

In summary, the optimization and specification of the EasySpray (Baxter Healthcare) and DuploSpray (Baxter Healthcare) applicator systems were demonstrated for the application of FG in ophthalmic surgery. The EasySpray (Baxter Healthcare) applicator system was most appropriate for conjunctival graft surgery based on the uniform thickness and spread of FG applied compared with the DuploSpray (Baxter Healthcare) applicator system. In the second part of the study, it was shown that the adhesive strength of sutures was greater than that of FG, although the adhesive strength of FG sprayed using an applicator was better than the manual drop-wise application technique; this did not reach statistical significance. It is concluded that the FG spray system designed for the ophthalmic system would be advantageous compared with the currently used manual drop-wise application method in several ways, including (1) an economical method as more applications can be performed; (2) a homogenous spread on the ocular tissue will provide better adhesion strength; and (3) a uniform thickness achieved on every application will provide superior wound healing properties of the tissue adhesion. Currently, a randomized clinical trial is being pursued to compare the efficacy of fibrin glue applied using easy spray applicator versus manual drop-wise application in pterygium surgery.

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