Abstract. Punctal plugs have offered a safe and often reversible treatment for aqueous-deficient dry eye for over three decades. However, they represent only one tool in our armamentarium to help patients with dry eyes, and plugs do have limitations. This article briefly reviews the history of occlusive treatments for aqueous tear deficiency and provides an update of recent advancements in punctal and canalicular occlusive materials and techniques. **(Comp Ophthalmol Update 7: 205-12, 2006)**

Key words. canalicular plug • dry eye • punctal occlusion • punctal plug

Introduction

Punctal plugs have offered a safe and often reversible treatment option for aqueous-deficient dry eye for over three decades.[1] This article briefly reviews the history of occlusive treatments for aqueous tear deficiency and provides an update of recent advancements in punctal and canalicular occlusive materials and techniques.

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Brief History

In 1935, Beetham reported the first successful treatment of dry eye symptoms by cautery occlusion of the tear drainage system.[2] Unfortunately, some patients developed epiphora from this permanent procedure. In 1961, Foulds proposed the use of dissolvable gelatin plugs prior to cautery to test which patients would benefit from permanent clos
Freeman developed the
reversible, long-term occlu
treatment using nondissol
punctal plugs in 1975.[1]
Over the past three deca
modifications to plug design
position have improved comfor
retention while minimi
complications. A wide variet
temporary and permanent mat
are now available in different sh
for punctal or intracanalic
placement.

Indications

Dry eye syndrome, keratoconjunctivitis sicca, has defined as a tear film abnorm resulting from either inadeq secretion or excessive evapora leading to ocular surface damag discomfort.[4] The cyclic natur ocular surface and lacrimal g inflammation, combined

Lagophthalmos
Persistent epithelial defect
Toxic epitheliopathy
Contact lens intolerance
Steven-Johnson syndrome

disruption of the normal reflex tearing feedback loop, often results in a highly variable association between discomfort and damage.[5] This lack of congruity between disease symptoms and signs complicates management and compliance.[6] Lacrimal outflow occlusion often offers more continuous relief, particularly for those patients who experience difficulty with topical therapy.

The defense of the corneal surface consists of an extraordinarily intricate system regulating tear secretion and blink rate (Figure 1). Normally, only 10% of secreted tears evaporate, while 90% typically drain into the nasolacrimal sac.[7] Punctal occlusion results in several immediate advantages. Increasing the tear lake volume provides aqueous support and prolongs the duration and amount of contact between the corneal epithelium and local growth factors and immunomodulatory cytokines.

A complex of sensory, sympathetic, and parasympathetic nerves links the lacrimal system into a homeostatic loop; its essential role is to protect and support the ocular surface. This homeostatic loop may ultimately limit the improvement achieved with lacrimal outflow occlusion. Punctal occlusion in normal subjects may decrease tear production and ocular surface sensation to invoke an autoregulatory mechanism that returns tear production, tear clearance, and ocular surface sensation to preocclusion levels 14 days to 17 days after punctal occlusion.[8] Corneal sensation, modulated through bradykinin and substance P secretion, tear nerve growth factor (NGF) levels, and neuronal nitric oxide synthase may play a role in modulating tear production.[8,9] While future treatments should solve aqueous-deficient dry eye by modulating this auto-regulatory mechanism, punctal plugs currently offer relief for many patients.

When considering punctal occlusion, other patient parameters affect occlusive treatment decisions. For example, female patients with similar aqueous-deficiency testing parameters as males may require more aggressive treatment. Significant reflex secretion may allow for occlusion of only the lower punctum, while its absence may call for both lower and upper outflow occlusion.

Numerous other disorders of the ocular surface may benefit from tear drainage occlusion as well (Table 1).[10] Occlusion also enhances the efficacy and safety of topical ocular medications by prolonging ocular availability and decreasing systemic absorption.[11,12] Temporary occlusion treats causes of transient dry eye and may allow for more outflow than the stenotic punctum.

Contraindications

Lacrimal drainage occlusive devices are contraindicated in patients with known allergy to the device material (silicone, bovine collagen, glycolic acid, trimethylene carbonate, etc.). Patients with signs of ocular infection or irritation (blepharitis or meibomian gland dysfunction) require further evaluation and treatment before considering tear drainage occlusion, as occlusion may increase local cytokines to increase irritation and epithelial destruction. Epiphora due to lacrimal drainage obstruction contraindicates placement of a lacrimal occlusive device.

Objective Measurements

While punctal and canalicular occlusion often provide relief of symptoms from aqueous tear deficiency, objective tests to reach the diagnosis and assess possible benefits of occlusion should be considered. Schirmer testing can be used to diagnose abnormal tear secretion.[16]

Focus Point #1

Recent modifications in plug design allow for increased tolerance and retention.

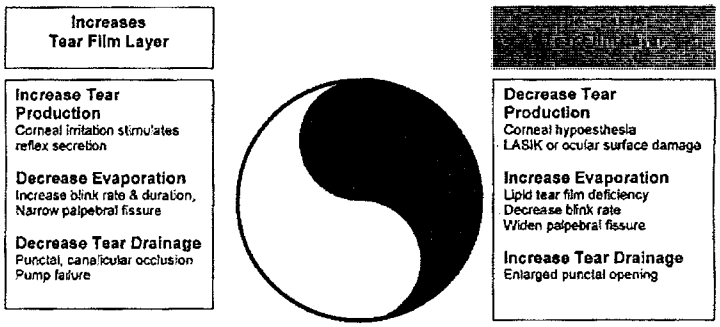

Fig. 1. Yin-Yang of a balanced lacrimal tear film.

Tear clearance can be assessed by the dye disappearance test to rule out lacrimal outflow obstruction as the cause of epiphora. Surface vital staining (fluorescein, lissamine green, rose bengal) and conjunctival impression cytology (decreased goblet cells, increased nucleo-cytoplasm ratio) confirm ocular surface damage.[17,18] Histologic improvements with punctal occlusion may take much longer than symptomatic relief.[19]

Because the tear film and cornea work together as a focusing lens, visual acuity can provide a quantitative measure of ocular surface dysfunction when acuity is diminished in the absence of other causes. Continuous visual acuity measurements improve after lacrimal occlusion,[20] and can help determine the need for further occlusive therapy. Tear quality can be assessed by the tear break-up time (BUT), which typically improves after punctal occlusion.[21] Tear meniscus height, an indicator of tear volume, also improves after occlusion.[22] Punctal occlusion increases tear quality by normalizing tear lactoferrin, lysozyme, osmolarity, IgA and albumin levels, although these measurements are not typically used clinically.[23,24]

While objective measures can help determine the need for and success of punctal occlusion therapy, subjective symptoms often guide therapy. Objective measures can underestimate symptoms, and a self-assessment questionnaire better measures symptoms and response to therapy.[25] Symptoms may also point to the likely response to plug therapy. In our experience, epiphora due to hypersecretion responds well to plug placement, while photophobia, which may be due to underlying inflammation, does not. Symptoms suggestive of underlying surface inflammation should be corrected prior to punctal plug placement.

Lacrimal Occlusive Devices

ABSORBABLE INSERTS: INTRACANALICULAR (VERTICAL OR HORIZONTAL)

Absorbable intracanalicular implants provide for safe and temporary relief of aqueous-deficient dry eyes. These temporary plugs were originally developed to predict the efficacy and tolerance of the more permanent occlusive procedures, such as electrocautery and silicone punctal plugs. A wide range of materials has been used, including gelatin,[3] gut suture,[26] and collagen plugs,[27] among others.[28] Collagen intracanalicular plugs come in a range of lengths (1.6 mm to 3 mm) and diameters (0.2 mm to 0.6 mm). The intracanalicular location allows for flexible sizing and avoids the discomfort associated with punctal dilation. Typical insertion techniques begin with instilling a drop of topical anesthetic. The rod-shaped implants can then be inserted under slit-lamp magnification using jeweler's forceps. Careful complete insertion into the vertical or horizontal canaliculi prevents ocular surface irritation.

Although reports show highly variable absorption rates, dry eye symptoms typically improve for 1-2 weeks. Patients are instructed to record symptoms and the need for supplemental lubrication for the first few days after insertion. Evidence of intolerance, including signs of allergies or epiphora, should be noted. Collagen plugs may improve dry eye parameters in similar amounts as silicone plugs in the short term, and satisfaction with intracanalicular collagen plugs can predict relief of symptoms with punctal plugs.[29] However, intracanalicular plugs only partially occlude outflow, so some patients who tolerate absorbable plugs can still develop epiphora with more permanent plugs.[22,30]

Newer, slower absorbing materials, such as PCL (E-caprolactone-L-lactide copolymer), monofilament (UltraPlug™, Surgical Specialties Corporation, Reading, PA), and the Extended Duration intracanalicular plug (Oasis Medical, Glendora, CA), offer similar ease of insertion, and last up to 6 months. The ProLong™ absorbable plug (FCI Ophthalmics, Marshfield Hills, MA), a copolymer of glycolic acid and trimethylene

Focus Point #2

Numerous ocular surface disorders may benefit from lacrimal drainage occlusion.

Oasis Silicone Plugs	Oasis Medical, Glendora, CA	Silicone, nonabsorbable	Punctal	Preloaded or reloaded	Sizes: 0.4–0.8 mm
SmartPlug™ (updated)	Medennium, Irvine, CA	Thermo-sensitive acrylic polymer, absorbable	Vertical canaliculus	Small box (storage); no punctal dilation required; difficulty reversal	Conforming
UltraPlug™	Surgical Specialties Corporation, Reading, PA	PCL monofilament, absorbable	Intracanalicular	N/A	Three sizes
Atelocollagen	Koken Biosciance Institutes, Japan	Injectable bovine dermis extract, absorbable	Intracanalicular	N/A	N/A
Snug Plug (FDA approval pending)	FCI Ophthalmics, Marshfield Hills, MA	Silicone, nonabsorbable	Punctal	One size fits all; no punctal dilation required; preloaded; one-step insertion	N/A
ProLong™	FCI Ophthalmics, Marshfield Hills, MA	Absorbable copolymer (~3 months)	Punctal	Ideal for post-LASIK	Three sizes: 0.3, 0.4, 0.5 mm in diameter and 2.0 in length
Ready-Set	FCI Ophthalmics, Marshfield Hills, MA	Silicone, nonabsorbable	Punctal	N/A	7 sizes (0.4–1.0 mm)
PVP Perforated Plugs	FCI Ophthalmics, Marshfield Hills, MA	Silicone with PVP coating	Punctal	For partial occlusion or stenosis	Sizes: 0.7 mm and 0.9 mm
SuperEagle™	Eagle Vision, Memphis, TN	Silicone, nonabsorbable	Punctal	Newest; good retention and comfort	Three sizes (range 0.4–1.1 mm)
SuperFlex™	Eagle Vision, Memphis, TN	Silicone, nonabsorbable	Punctal	Good retention and comfort; easy insertion; multiple sizes	8 sizes (0.4–1.1 mm)
Flow Controller	Eagle Vision, Memphis, TN	Silicone, nonabsorbable	Punctal	For partial punctal occlusion; tapered shaft	4 sizes (0.5–0.8 mm)
Eagle FlexPlug™	Eagle Vision, Memphis, TN	Silicone, nonabsorbable	Punctal	Flexible; good fit and comfort	8 sizes (0.4–1.1 mm)
EaglePlug™	Eagle Vision, Memphis, TN	Silicone, nonabsorbable	Punctal	Original plug; inexpesnive	5 sizes (0.4–0.8 mm)
DuraPlug™	Eagle Vision, Memphis, TN	PCL, absorbable (60–180 days)	Punctal-canalicular	Ideal for post-LASIK	N/A
Parasol® Plus™ Occluder	Odyssey Medical, Inc., Memphis, TN	Silicone, nonabsorbable	Punctal	N/A	Sizes: small (0.4 mm) to extra-large (0.9 mm)
Parasol® Punctal Occluder	Odyssey Medical, Inc., Memphis, TN	Silicone, nonabsorbeble	Punctal	Self-dilating plug	Sizes: extra-small (0.2 mm) to large (0.9 mm)
Quintess™	Cynacon/Ocusoft, Inc., Richmond, TX	Silicone, nonabsorbable	Punctal	Minimal foreign body sensation	Sizes: 0.3–0.9 mm
Collagen	Various manufacturers	Collagen, absorbable (days)	Punctal	For trial of punctal occlusion	N/A

defects.[33] The intracanalicular location provides significantly less ocular surface irritation and risk of extrusion than punctal plugs. These absorbable materials may carry less risk of infection, untoward inflammation, and permanent canalicular obstruction compared to permanent materials.

NONABSORBABLE INSERTS: PUNCTAL PLUGS

The original permanent punctal plug described by Freeman in 1975 resembled an asymmetric dumbbell configuration. When placed properly, these plugs sit visibly at the punctum, with a wide internal anchoring bulb portion that prevents extrusion, and an external cap or collar that prevents the plug from descending into the canaliculus. A narrow cylindrical shaft connects the bulb and the collar. This basic punctal plug design preserves the remaining secreted tears against the ocular surface.

Design Variations

Recent modifications to the component sections and materials have improved comfort and fit while minimizing risks of spontaneous loss, extrusion, or downward migration.

Focus Point #3

Newer absorbable materials offer longer relief of dry eye symptoms.

Fig. 2. External photograph demonstrates erythema and edema consist with acute canaliculitis in the area of a previously placed canalicular plug. infection resolved after a course of topical and oral antibiotics, and surg removal of the occlusive device.

Variations in the collar, such as the slanted collarette offered on some Ready-Set models (FCI Ophthalmics, Marshfield Hills, MA), may improve the profile over the punctum. This plug line also offers the Slim plug, with a smaller bulb for easier insertion.

Some plugs offer a central perforation. One version, the PVP plug (FCI Ophthalmics, Marshfield Hills, MA) is lined with polyvinylpyrrolidone to prevent mucous from occluding the lumen. This lumen may allow for some tear outflow.[14,15] The Parasol® occluder (Odyssey Medical, Inc., Memphis, TN) is hollow, but to allow for collapse and easier fit, rather than for partial outflow. The Parasol® Plus™ offers contoured edges with a solid nose.

While the PVP plug uses a silicone-lined material, other plugs use silicone rubber to change performance characteristics. The Quintess™ plug (Cynacon/Ocusoft, Inc., Richmond, TX) offers microreservoir collarette indentations to create a barrier between the plug and the ocular surface.

Some newer plugs decrease the need for sizing. Snug Plug (FCI Ophtalmics, Marshfield Hills, MA, FDA approval pending) is a silicone punctal plug manufactured in universal size. The SuperEag (Eagle Vision, Memphis, T another newer silicone plug, cor in three sizes. This plug has a tape shaft and a flexible nose to allow easier placement without punc gauging.

Insertion Technique

A typical insertion technique nonabsorbable silicone punctal pl is described below; however, spec variations should follow manuf turer's recommendations. Topi anesthesia with a drop of 0. proparacaine instilled into conjunctival cul-de-sac is usu sufficient. Some patients, howev may benefit from applying dir pressure on the punctum using a lidocaine-soaked cotton applica Manufacturers typically offer punc size gauging systems for th products, which can minimize waste of trial-and-error techniqu Optimal sizing balances the risk extrusion and downward migrat for plugs that are too small with risk of pyogenic granulo formation and discomfort associa with plugs that are too big.[34-36] T ideal plug size should fit with ger pressure.

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