Review Article

Management options of acquired punctal stenosis

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ABSTRACT

تضيق فتحة مجرى العين حالة شائعة للمرضى المحولين لعيادة جراحة العيون والبحث عن طريقة لإزالة الدمع بشكل دائم بدون أي طرق جراحية أو تغيرات على قناة الدمع بدأت في هذا العصر ومنذ قرون. في هذا الاستعراض نلخص جميع الطرق المستخدمة في الأدب الطبي الانجليزي مع وصف الطرق المستخدمة، ومعدل النجاح المحقق، والمضاعفات المحتملة، وذلك للتعرف على طرق العلاج الفعالة المستخدمة لعلاج تضيق فتحة مجرى العين المكتسب اعتماداً على المعلومات المتوفرة حالياً.

Punctal stenosis is a frequent source of patients referral to the otoplasty clinic and the search for a procedure that can permanently eliminate epiphora without disturbing the normal lacrimal system anatomy and physiology started centuries ago and continues today. The following article summarizes the reported procedures in the English literature in the acquired punctal stenosis with a description of techniques, success rates, and potential complications with the goal of identifying the most effective treatment strategy based on the current knowledge available.

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Acquired punctal stenosis is one of the most commonly encountered diseases causing tearing.[1,2] The basis for the current treatment options is enlargement of the punctum by either dilatation and insertion of prosthetic material namely perforated punctal plugs (PPP), mini-monoka canalicular stents (MMC) or self retaining bicanalicular stents (SRBC) or by snip incisions, which can also be supplemented by prosthetic insertion, adjuvant MMC application, or by simple repeated dilatation to overcome the possibility of fibrosis and restenosis. Researchers have not reached a consensus on which procedure is best, and a comparison of the different techniques is difficult due to the limited number of studies. This article will present the principles of the management options available up to date and the challenging issues of finding the most likely procedure available with the highest success rate to conquer this disease.

Method of literature search. All English articles pertaining to punctal stenosis were sought using Medline, PubMed and Cochrane library (all years). The following research terms were used: punctal stenosis, punctal plug, mini Monoka, punctoplasty, snip procedure, upper lacrimal system and tearing.

Punctal anatomy and physiology. Studies showed a great variability in the normal size of the punctum not only because they tend to vary in size among different individuals, but also as a result of the use of different measuring methods.[3] While textbook parameters range from 0.2-0.5mm,[4,5] a study using computerized measurements of the punctal size in normal adults showed that the normal upper punctum has a mean area of 0.264 mm^2 and the lower punctum has a mean area of 0.321 mm. It also showed that the upper puncta tend to be smaller than the lower puncta and there is no size difference between men and women nor any size difference in the right and left sides.[6] Another study using direct observation and assessment of punctal size using graduated eyepiece showed that the mean diameter of a normal punctum is 0.1 mm. It also showed a statistically significant correlation of the punctal size with advancing age.[7]

In order for the tears to flow through the punctum into the other lacrimal drainage system passageways, the lacrimal pump mechanism has to be intact. This theory was proposed in the early 1980s describing the effect of blinking on tear flow within the lacrimal drainage system.[8] Using a high-speed photograph, it has been confirmed that the punctal openings elevate from the lid margin at the start of the closing phase of the blink, allowing their forceful meeting and occlusion by the time the closing lid is half way down. Complete lid closure leads to compression of the canaliculi and lacrimal sac forcing the fluid to move down along the

drainage system. During the opening phase of the blink, the canaliculi expand creating a suction power for the tears. During the later part of this opening, when the punctai move apart, the vacuum is broken and tear fluid from the marginal tear strips is drawn into the puncta in the first few seconds of the blink. Additionally, ultrasound studies have documented the role of the orbicularis oculi muscle and medial canthal tendon in creating pressure changes within the lacrimal sac to draw tears along the canaliculi via capillary attraction.[9]

Prevalence. The incidence of punctal stenosis has not yet been studied, but there are 2 reports on the prevalence of the disease. Out of 682 patients seen in a hospital-based population, 54.3% had an element of punctal stenosis with a statistically significant correlation with advancing age and concomitant chronic blepharitis.[2] The other study showed a prevalence of 17.3% of punctal stenosis among 621 participants from the general population.[1] It also showed a significant correlation with advancing age but not with chronic blepharitis. In this study, a statistically significant correlation was found with sun exposure and outdoor occupational activities.

Although both studies used the Kashkouli's grading method[3] to diagnose punctal stenosis and the discrepancy in their results might be explained by the difference in the selection method as the first was hospital based and the second was population based. Other factors that may cause the difference in the prevalence rate include the geographical location and the prevalence of chronic blepharitis in the studied population as it is most commonly associated disease found in punctal stenosis patients.[2,6,10]

Etiology. Many local and systemic diseases[2,10-24] have been linked to the development of acquired punctal stenosis via induction of chronic inflammatory reaction either as part of the inflammatory condition or in response to irritant exposure. The chronic inflammation leads to activation of macrophages and lymphocytes causing the release of cytokines and growth factors namely tumor necrosis factor, interleukin-1, interlukin-4, fibroblast growth factor and transforming growth factor-β. Those factors induce proliferation of fibroblasts and increase in collagen synthesis. At the same time, chronic inflammation inhibits matrix metalloproteinase activity leading to decreased collagen degradation.[25] **Table 1** lists the etiological factors for acquired punctal stenosis.

Clinical assessment. On clinical settings, ophthalmologists tend to diagnose punctal stenosis when the punctum diameter is less than 0.3 mm on slit lamp biomicroscopic examination or when they are unable to introduce a 26 G cannula without punctal dilatation, although false results can be obtained from stretching the punctal walls during cannula insertion.[24] It can cause epiphora with and without the presence of other diseases such as lid laxity, lid margin malposition, anterior segment disease like pterygium, canalicular obstruction, nasolacrimal duct obstruction or dry eye with reflex tearing.[27]

In spite of the significance of precisely estimating the grade of punctal stenosis enable to develop a standardized terms to compare the outcome of different studies, there is still no universally accepted agreement on a grading method. Kashkouli et al[10] (**Table 2**) proposed a clinical

Table 1 - Causes of acquired punctal stenosis (modified from Soiberman et al[26]).

Aging
Inflammatory
Chronic blepharitis
Dry eye syndrome
Ectropion
Ocular cicatricial pemphegoid
Stevens Johnson syndrome
Graft versus host disease
Infectious conjunctivitis
Topical medications
Anti-glucoma medications
Mitomycin C
Epinephrine
Systemic medications
5-Fluorouracil
Docetaxel
Paclitaxel
Idoxuridine
Systemic diseases
Acrodermatitis enteropathica
Porphyria
Peripunctal tumor
Trauma
Facial radiotherapy
Idiopathic

Table 2 - Grading of external lacrimal punctum (Kashkouli et al[10]).

Grade	Clinical finding on slit lamp examination; insertion method for a bowman probe number 00*.
0	No papilla and punctum (punctal atresia); surgery is needed to create a papilla
1	Papilla is covered by a membrane; a # 25 needle, followed by punctal finder. Exudative or true membrane or fibrosis difficult to recognize with standard punctum dilator
2	Less than normal size, but recognizable; a punctal finder and then a standardized punctum dilator required
3	Normal; regular punctum dilator required
4	Small slit (<2mm); no intervention required
5	Large slit (≤2mm); no intervention required

*level of inter-observer reliability.

Table 3 - Published studies on management of acquired punctal stenosis.

Author	Study description	Results
Caesar & McNab[37] 2005	Design: Retrospective chart review Procedure: Rectangular 3-snips Location: UK Number of patients: 53 Number of eyelids: 102 Follow up period: NA	Anatomical success: NA Functional success: 92% Complication: None
Shahid et al[38] 2008	Design: Retrospective chart review Procedure: Triangular and Rectangular 3-snips Location: UK Number of patients: 135 Number of eyelids: 205 Follow up period: 23 months	***Anatomical success:*** Triangular: 94.1% Rectangular: 91.1% ***Functional success:*** Triangular: 62.5% Rectangular: 71.4% Complication: None
Chak & Irvine[39] 2009	Design: Retrospective chart review Procedure: Triangular and rectangular 3-snips Location: UK Number of patients: 75 Number of eyelids: 108 Follow up period: 8 months	***Anatomical success:*** Triangular: 96.6% Rectangular: 93.9% ***Functional success:*** Triangular: 83.1% Rectangular: 89.8% Complication: None
Kim et al[42] 2012	Design: noncomparative case series Procedure: 4-snips punctoplasty Location: Korea Number of patients: 26 Number of eyelids: 45 Follow up period: 6 months	Anatomical success: 88.9% Functional success: 93% Complication: None
Kashkouli et al[33] 2005	Design: Prospective, noncomparative interventional case series Procedure: 1-snip punctoplasty with MM Location: Iran Number of patients: 35 Number of eyelids: 53 Follow up period: 18.5 months	Anatomical success: 96.2% Functional success: 77.4% Complication: None
Chalvatis et al[41] 2013	Design: Prospective, randomized, comparative study Procedure: Rectangular 3-snips versus rectangular 3-snips with self retained bicanalicular stent Location: Greece Number of patients: 16 Number of eyelids: 32 Follow up period: 6 months	***Anatomical success:*** 3-snips alone: 31.2% 3-snips+ stent: 81.2% ***Functional success:*** 3-snips alone: 18.7% 3-snips + stent: 62.5% Complications: Stent loss, stent migration, transient ocular surface irritation.
Kristan[32] 1988	Design: case report Procedure: 1-snip punctoplasty with MMC Location: USA Number of patients: 1 Number of eyelids: 1 Follow up period: 3 months	Anatomical success: Patent punctum Functional success: Resolved epiphora Complication: None
Konuk et al[49] 2008	Design: Retrospective review Procedure: Punctal dilatation and perforated punctal plug Location: Turkey Number of patients: 26 Number of eyelids: 44 Follow up period: 19 months	Anatomical success: NA Functional success: 84.1% Complication:
Malet et al[47] 1998	Design: Prospective comparative study Procedure: Comparison of silicone and PVP coated silicone perforated punctal plugs Location: France Number of patients: 40 Number of eyelids: 40 Follow up period: 6 months	Anatomical success: NA Functional success: No epiphora Complication:

UK - United Kingdom, MMC - mini-monoka canalicular stents, PVP - polyvinylpyrrolidone, NA - not applicable

grading method in 2003 and confirmed its level of inter observer reliability in 2008.[3,10] This method seems to be the most clinically applicable method as it is based on punctal shape and size on slit lamp examination as well as the ease in introducing a punctal dilator.

Treatment options. The basis for the current treatment options for acquired punctal stenosis is surgical or non-surgical enlargement of the punctum with or without prosthetic material insertion namely PPP, MM stent and self-retaining bi-canlicular stents to overcome the possibility of fibrosis and restenosis.

Snip punctoplasty. ***One-snip punctoplasty.*** One of the earliest methods proposed to achieve punctal enlargement, 1-snip punctoplasty, by making a single incision with a sharp-tip Westcott scissors along the horizontal canaliculus after infiltration of local anesthesia.[28,29] Because that technique can damage the capillary attraction of the canaliculus, a modification by changing the direction of the incision to a single vertical incision down the ampulla has been made.[30] However, as any incision has a tendency for re-approximation during the healing phase, several modifications had been proposed. One of the earliest proposals that did not gain any popularity was puckering suture.[31] This is performed after completing a 1-snip procedure by passing a 4.0 non-absorbable double-armed suture through the lateral lower lid tarsus and then through the temporalis fascia or periosteum laterally to keep the incision edges apart during the healing phase. Sterile cotton is then used at both anchorages to prevent cheese wiring of the suture through the tissues. The tension of the suture to spread the punctal incision is then adjusted and the sutures should be removed after 3-5 days.

Simpler modifications have been also proposed involving the additional insertion of PPP32 or MM33 stents. With PPP, care should be taken not to place the superior lip of the plug too far into the canaliculus as this can complicate retrieval. While with MM, it should measures the distance from the punctum to the lacrimal sac using a Bowman probe to determine the length of the MM stent, which should be 2 mm more than the recorded distance, and the snip should be carried out on the nasal side of the punctum to provide better insertion and fixation of the stent. Mini-monoka canalicular stents has the advantage of addressing the issue of concomitant canalicular stenosis that can be associated with 46% of patients with punctal stenosis.

Adjuvant use of MMC has been also introduced in order to overcome fibrosis.[34] It can applied using a soaked cellulose sponge with 0.04% mitomycin solution and on the punctal opening for 5 minutes, followed by extensive irrigation with balanced salt solution.

Three-snip punctoplasty. Triangular 3-snip punctoplasty was first described in the 1950s[35,36] as an attempt to overcome the re-approximation of cut edges after 1-snip punctoplasty by making a vertical cut incision along the posterior wall of the ampulla using vannus scissors, then a horizontal cut along the roof of the canaliculus to create a flap then remove the base of the flap. Later, modifying the shape of the 3 snips from triangular to rectangular was suggested to avoid disruption of the horizontal canaliculus,[37-39] which is vital for the proper function of the lacrimal pump mechanism. This was carried out by holding the posterior wall of the ampulla with a toothed forceps then making 2 vertical cuts on both sides of the forceps then a third cut across the bottom to conclude the procedure. The adjuvant use of MMC with triangular 3-snip punctoplasty has been suggested to enhance the success rate of the procedure.[40] This is performed by soaking a cotton-tipped applicator in 0.5 mg/ml MMC and place it over the punctal opening then changing it every one minute for a total of 5 minutes followed by copious irrigate the area with saline. Recently, the use of self-retaining bi-canalicular stents in conjunction with rectangular 3-snips punctoplasty has been suggested showing a higher anatomical and functional success rate than patients underwent quadrangular 3-snips alone.[41] The bi-canalicular intubation should be conducted after performing a quadrangular 3-snips punctoplasty in the usual method, that is essential to safely secure the upper end of the stent into the common canaliculus to prevent any back sliding while the lower end is inserted. Once the stent is secured in place, the patient should be asked to blink a few times, and a slight pressure is applied on the inner canthal area to ensure good fixation. A safe criterion for correct stent size is to avoid contact of the stent to the cornea when the eye is in adduction. The stent should be kept in place for 6 weeks then removed it by pulling them out under slit lamp guidance.

Four-snip punctoplasty. Four-snip punctoplasty was recently proposed to overcome severe punctal stenosis that cannot accommodate the 2 vertical incisions needed for rectangular 3-snip punctoplasty[42] by making a small vertical incision down to the ampulla; then, a second 2-mm horizontal cut along the roof of the canaliculus. Then a third vertical cut from the edge of the second and a horizontal cut from the edge of the first cut to create a flap, which can then be removed by cutting the base.

Punctal prosthesis. Since all surgical procedures to treat punctual stenosis carry the risk of fibrosis during the healing phase with resultant restenosis, the use of prosthetic devices has been suggested to keep the

punctum dilated during healing. Various prosthetic materials have been used, including nasolacrimal silicone tubes, MM stents, and perforated punctual plugs and bi-canalicular stents.[43-55]

Mini monoka stents. Monocanalicular silicone MM stents consist of circular perforated collarets that allow stable fixation and prevent migration and a hollow cylindrical neck linking the collaret to the bulb, which is followed by a 25-mm silicone tube with an outer diameter of 0.64 mm. The bulbous joint helps stabilize the MM within the ampulla. Mini monoka stents were first used for repair of canalicular injuries and later for the management of punctal stenosis, sometimes in conjunction with snip punctoplasty.[32,33] Punctal and canalicular dilatation and probing up to the lacrimal sac should be undertaken to ascertain the length of the stent required which must be 2 mm longer than the length of the canalicular stenosis if present. When no canalicular stenosis is present the MM stent should be the distance from the punctum to the sac, which is usually 12 mm. The end needs to be cut obliquely to enable easier insertion into the canalicular system. To introduce MM into the lacrimal system, one needs to hold the eyelid lateral to the punctum using a toothed Adsons forceps for proper stabilization, and then advance the tube through the punctum and the canalicular system until the bulb reaches the ampulla. Hold the MM stent neck with a fine-toothed forceps (namely, St Martin) and insert a Nettleship dilator in the perforation in the head. Use the dilator to guide the bulb into the punctum, using a moderate amount of pressure in a medial and downward direction. Keep the eyelid stretched while the bulb is maneuvered in the punctum. Ensure that the head sits flat on the lid margin. Remove the MM stent after at least 6 weeks.

Perforated punctal plugs. Perforated punctal plugss were first introduced by Bernard et al in France as a modification for the punctual plugs used for treatment of dry eyes; a central perforation of 0.6 mm was made to allow tears to drain. The early versions of the perforated plugs were not successful because accumulated secretions soon blocked the perforated area due to the hydrophilic nature of the silicone material. This problem was solved by coating the plug with polyvinylpyrrolidone (PVP), a material that is hydrophobic and allows tears and debris to flow smoothly through the perforation.[43] due to the large size of the PPP the treated punctum has to be adequately dilated using progressively enlarging Bowmann probes. After plug insertion the high end of the plug collar must be toward the nasal end of the punctum to achieve optimal fit against the lid margin. Plug is then removed after 2 months.

Wedge punctoplasty. Wedge punctoplasty involves a punch incision in the posterior wall of the punctum and vertical canaliculus to create a funnel effect in which tears are drawn toward the open punctum. The wedge shape of the resultant incision is supposed to prevent apposition of the cut edges without disturbing the lacrimal pump. This procedure can be conducted using either Kelly punch[56] or Reiss punch.[57,58] it is performed by introducing the tip of the punch in the ampulla with some posterior angulation so it is possible to excise and cut tissue from the posterior wall. This can be repeated to achieve the optimum punctal enlargement.

Microsurgical punctoplasty. Microsurgical punctoplasty was introduced in 1993,[59] with the basic idea of enlarging the punctum without disturbing its anatomy and without using any synthetic material. However, it did not gain any popularity. It is performed by placement of 00 Bowman probe in the canaliculus then using a Beaver no. 75 blade or equivalent to make a 360° incision on the stenotic punctum, then grasp the incised punctum with 0.12-mm forceps and free the vertical canaliculus from the attachment to the surrounding tissues. Make a 1-2 mm incision using Westcott scissors at the medial and lateral extent of the punctum and then excise the hypertrophied punctum in halves revealing the exposed end of the vertical canaliculus. Make further relaxing incisions in the vertical canaliculus medically and laterally, if necessary, to facilitate the externalization and suturing of the vertical canaliculus. Place multiple interrupted 10.0 nylon sutures in a radial fashion for 360°, suturing the externalization vertical canaliculus to the lid margin and externalizing the ampulla of the vertical canaliculus; 8-12 interrupted 10.0 sutures are needed.

Laser punctoplasty. Laser punctoplasty was proposed in 1985[60] for punctal occlusions due to an overgrowth of the conjunctival epithelium that occurs with aging or scar tissue created by low-grade inflammation, but it was never widely used. After marking the punctum under the conjunctival overgrowth by identifying the dark blue spot under the slit lamp. Treat the marked area with a central burn, using an argon laser (200-µm spot, 0.2 second exposure time, 1,200-1,500 mW of power) followed by concentric burns until a sufficiently large area has been melted away.

Cautery application. Cautery application was proposed in 1977 using retraction rather than dilatation to open a stenotic punctum in the lower lid,[61] but it did not gain any popularity. With the patient's eye directed upward and the lower lid slightly everted, dilate the punctum and the canaliculus. Apply a low-powered cautery to the base of the lacrimal papilla. Take care

that the cautery penetrates only through the surface epithelium and just into the muscle layer because deeper penetration may cause scarring of the connective tissue ring or of the mucosal lumen itself.

Punctal re-dilatation. This is an additional procedure that can be combined with any punctoplasty surgery by applying an office punctal re-dilatation if patients showed signs of cicatrization at their postoperative appointments.[62] Apply punctum dilatation using lacrimal dilator that is advanced into the proximal canaliculus to release cicatricial changes. Repeat this technique at every follow-up visit if signs of fibrosis and re-approximation are noted. **Table 3** demonstrates all the published studies on the management of acquired punctal stenosis.

Treatment outcomes. Based on the available data recurrent epiphora due to fibrosis and re-stenosis is the most common cause of treatment failure in all treatment modalities. Despite of the improvement in the success rate with the introduction of punctal prosthetics, another set of potential complications emerged including, plug extrusion, canalicular stenosis, plug migration with resultant canaliculitis and dacryocystitis.[50-56] The possibility of tumorigenesis, such as granuloma and papilloma has also been noted.[63] A recent report of reactive lymphoid hyperplasia that occurred 3 years after insertion of a lacrimal canaliculus silicone plug[64] has to be taken seriously and investigated thoroughly because lymphoma has been linked to silicone breast implants and joint prostheses.[65,66] Additionally, although reactive lymphoid hyperplasia is considered benign, it has been shown to be a precursor for conjunctival malignant lymphoma.[67] Mini monoka stents canalicular stents has the advantage over PPP in addressing canalicular stenosis, which is associated with punctal stenosis in 46% of the cases,[68] but it also carries the risk of extrusion, split punctum, canalicular fistula and corneal abrasion.[44,46] While MMC can prevent fibrosis and restenosis, care must be taken as animal studies showed an association between MMC use and decrease in the amount of collagen and elastin fibers in the canaliculi with a resultant decrease in its basal tension and elasticity in rabbits.[69] Such changes would theoretically damage the lacrimal pump mechanism and affect the long-term success rate. In addition, MMC has been shown to cause punctal and canalicular stenosis when used as a topical treatment for ocular surface neoplasia.[70] the possible mechanisms are toxoallergic reaction, nonspecific inflammation causing epithelial sloughing, and subepithelial fibrosis, eventually leading to stenosis. The required drug dose and the duration for such an inflammation to occur is not known. Therefore, long-term follow-up studies on patients that had adjuvant MMC therapy for punctal stenosis are needed.

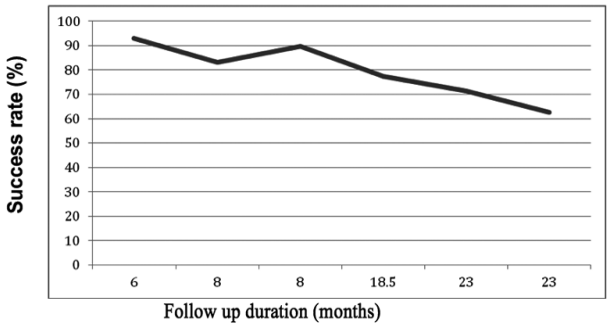

Figure 1 - Relationship between success rate and duration of follow up in published studies.

In conclusion, acquired punctal stenosis can be a devastating disease to a significant number of patients as a result of the resultant visual disturbance and the social embarrassment from constant epiphora and comparing the different treatment options for acquired punctal stenosis is difficult due to several factors including the very limited number of studies on any given procedure, the deficiency of a universally acceptable method to grade the punctal size which is needed not only to standardize the definition of punctal stenosis but also to define anatomical success. The failure to address the presence of chronic eyelid margin inflammations, namely chronic blepharitis in the studied population and if any treatment has been given is another factor shared by the majority of the published studies. As chronic blepharitis can be the predisposing factor for the development of punctal stenosis, it can very well be the main cause of treatment failure over time (**Figure 1**) most likely due to the chronic fibrosing nature of the disease, therefore it might be possible to improve the success rate if any treatment modality is prefixed with treatment of chronic blepharitis, a theory needs to be investigated and more studies with prolonged follow up periods not only to suggest new treatment modalities, but also to evaluate the current methods.

At the present time, quadrangular 3-snips punctoplasty is the most commonly studied procedure with a high success rate possibly due to the theoretical preservation of the lacrimal pump mechanism. The risk of fibrosis and re-stenosis is present in all the available treatment modalities and the attempt to overcome it by using adjunct punctal prosthetics and mitomycin C has to be weighed against the additional complications.

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References

1. Viso E, Rodríguez-Ares MT, Gude F. Prevalence and associations of external punctal stenosis in a general population in Spain. ***Cornea*** 2012; 31: 1240-1245.
2. Bukhari A. Prevalence of punctal stenosis among ophthalmology patients. ***Middle East Afr J Ophthalmol*** 2009; 16: 85-87.
3. Kashkouli MB, Nilforushan N, Nojomi N, Rezaee R. External lacrimal punctum grading: reliability and interobserver variation. ***Eur J Ophthalmol*** 2008; 18: 507-511.
4. Kakizaki H, Takahashi Y, Iwaki M, Nakano T, Asamoto K, Ikeda H, et al. Punctal and canalicular anatomy: implications for canalicular occlusion in severe dry eye. ***Am J Ophthalmol*** 2012; 153: 229-237.
5. Ball JM. Modern Ophthalmology: A Practical Treatise on the anatomy physiology, and diseases of the Eye. 5th ed. Philadelphia (PA): FA Davis; 1926.
6. Carter KD, Nelson CC, Martonyi CL. Size variation of the lacrimal punctum in adults. ***Ophthal Plast Reconstr Surg*** 1988; 4: 231-233.
7. Patel S, Wallace I. Tear meniscus height, lower punctum lacrimale, and the tear lipid layer in normal aging. ***Optom Vis Sci*** 2006; 83: 731-739.
8. Doane MG. Blinking and the mechanics of the lacrimal drainage system. ***Ophthalmology*** 1981; 88: 844-851.
9. Pavlidis M, Stupp T, Grenzebach U, Busse H, Thanos S. Ultrasonic visualization of the effect of blinking on the lacrimal pump mechanism. ***Graefes Arch Clin Exp Ophthalmol*** 2005; 243: 228-234.
10. Kashkouli MB, Beigi B, Murthy R, Astbury N. Acquired external punctal stenosis: etiology and associated findings. ***Am J Ophthalmol*** 2003; 136: 1079-1084.
11. Weston BC, Loveless JW. Canalicular stenosis due to topical use of fortified antibiotics. ***Can J Ophthalmol*** 2000; 35: 334-335.
12. Esmaeli B, Valero V, Ahmadi MA, Booser D. Canalicular stenosis secondary to docetaxel (taxotere): a newly recognized side effect. ***Ophthalmology*** 2001; 108: 994-995.
13. Lee V, Bentley CR, Olver JM. Sclerosing canaliculitis after 5-fluorouracil breast cancer chemotherapy. ***Eye*** (Lond) 1998; 12: 343-349.
14. Billing K, Karagiannis A, Selva D. Punctal-canalicular stenosis associated with mitomycin-C for corneal epithelial dysplasia. ***Am J Ophthalmol*** 2003; 136: 746-747.
15. Tabbara KF, Bobb AA. Lacrimal system complications in trachoma. ***Ophthalmology*** 1980; 87: 298-301.
16. Seiff SR, Shorr N, Adams T. Surgical treatment of punctal-canalicular fibrosis from 5-fluorouracil therapy. ***Cancer*** 1985; 56: 2148-2149.
17. Schwab IR, Linberg JV, Gioia VM, Benson WH, Chao GM. Foreshortening of the inferior conjunctival fornix associated with chronic glaucoma medications. ***Ophthalmology*** 1992; 99: 197-202.
18. O'Donnell FE Jr. Medial ectropion: association with lower lacrimal obstruction and combined management. ***Ophthalmic Surg*** 1986; 17: 573-576.
19. McNab AA. Lacrimal canalicular obstruction associated with topical ocular medication. ***Aust N Z J Ophthalmol*** 1998; 26: 219-223.
20. Jager GV, Van Bijsterveld OP. Canalicular stenosis in the course of primary herpes simplex infection. ***Br J Ophthalmol*** 1997; 81: 332.
21. Brink HM, Beex LV. Punctal and canalicular stenosis associated with systemic fluorouracil therapy. Report of five cases and review of the literature. ***Doc Ophthalmol*** 1995; 90: 1-6.
22. Cherry PM, Falcon MG. Letter: Punctal stenosis-caused by idoxuridine or acrodermatitis enteropathica? ***Arch Ophthalmol*** 1976; 94: 1632.
23. McCartney E, Valluri S, Rushing D, Burgett R. Upper and lower system nasolacrimal duct stenosis secondary to paclitaxel. ***Ophthal Plast Reconstr Surg*** 2007; 23: 170-171.
24. Port AD, Chen YT, Lelli GJ Jr. Histopathologic changes in punctal stenosis. ***Ophthal Plast Reconstr Surg*** 2013; 29: 201-204.
25. Kumar V, Robins SL, Cotran V. Pathologic basis of disease, Philadelphia (PA): Saunders, an imprint of Elsevier Inc.; 2010.
26. Soiberman U, Kakizaki H, Selva D, Leibovitch I. Punctal stenosis: definition, diagnosis, and treatment. ***Clin Ophthalmol*** 2012; 6: 1011-1018.
27. Mainville N, Jordan DR. Etiology of tearing: a retrospective analysis of referrals to a tertiary care oculoplastics practice. ***Ophthal Plast Reconstr Surg*** 2011; 27: 155-157.
28. Bowman W. Methode de traitement applicable a l'epiphora dependent du renversement en dehors ou de l'oblitration des points lacrymaux. ***Ann Oculist*** 1853; 29: 52-55. [French]
29. Arlet F. Operation an den thranenwegen. In: Graefe A, Saemisch T, editors. Handbuch der Gesammten Augenheilkunde. Leipzig, Germany: Verlag Von Wilhelm Englemann; 1874. p. 479-480.
30. Jones LT. New lacrimal developments. In: Mustarde JC, Jones LT, Callahan A, editors. Ophthalmic plastic surgery up-to-date. Birmingham: Aesculpius Publishing Co; 1770. p. 96.
31. Dolin SL, Hecht SD. The punctum pucker procedure for stenosis of the lacrimal punctum. ***Arch Ophthalmol*** 1986; 104: 1086-1087.
32. Kristan RW. Treatment of lacrimal punctal stenosis with a one-snip canaliculotomy and temporary punctal plugs. ***Arch Ophthalmol*** 1988; 106: 878-879.
33. Kashkouli MB, Beigi B, Astbury N. Acquired external punctal stenosis: surgical management and long-term follow-up. ***Orbit*** 2005; 24: 73-78.
34. Lam S, Tessler HH. Mitomycin as adjunct therapy in correcting iatrogenic punctal stenosis. ***Ophthalmic Surg*** 1993; 24: 123-124.
35. Thomas JB. A modification of Graves' operation for epiphora due to stenosis of the lacrimal punctum. ***Br J Ophthalmol*** 1951; 35: 306.
36. Viers E. Disorders of the lacrimal canaliculus. The lacrimal system. New York (NY): Grune & Stratton; 1955. p. 46-47.
37. Caesar RH, McNab AA. A brief history of punctoplasty: the 3-snip revisited. ***Eye (Lond)*** 2005; 19: 16-18.
38. Shahid H, Sandhu A, Keenan T, Pearson A. Factors affecting outcome of punctoplasty surgery: a review of 205 cases. ***Br J Ophthalmol*** 2008; 92: 1689-1692.
39. Chak M, Irvine F. Rectangular 3-snip punctoplasty outcomes: preservation of the lacrimal pump in punctoplasty surgery. ***Ophthal Plast Reconstr Surg*** 2009; 25: 134-135.
40. Ma'luf RN, Hamush NG, Awwad ST, Noureddin BN. Mitomycin C as adjunct therapy in correcting punctal stenosis. ***Ophthal Plast Reconstr Surg*** 2002; 18: 285-288.
41. Chalvatzis NT, Tzamalis AK, Mavrikakis I, Tsinopoulos I, Dimitrakos S. Self-retaining bicanaliculus stents as an adjunct to 3-snip punctoplasty in management of upper lacrimal duct stenosis: a comparison to standard 3-snip procedure. ***Ophthal Plast Reconstr Surg*** 2013; 29: 123-127.

42. Kim SE, Lee SJ, Lee SY, Yoon JS. Outcomes of 4-snip punctoplasty for severe punctal stenosis: measurement of tear meniscus height by optical coherence tomography. ***Am J Ophthalmol*** 2012; 153: 769-773.
43. Fayet B, Bernard JA. A monocanalicular stent with self-stabilizing meatic fixation in surgery of excretory lacrimal ducts. Initial results. ***Ophtalmologie*** 1990; 4: 351-357.
44. Mauriello JA Jr, Abdelsalam A. Use of a modified monocanalicular silicone stent in 33 eyelids. ***Ophthalmic Surg Lasers*** 1996; 27: 929-934.
45. Mathew RG, Olver JM. Mini-monoka made easy: a simple technique for mini-monoka insertion in acquired punctal stenosis. ***Ophthal Plast Reconstr Surg*** 2011; 27: 293-294.
46. Hussain RN, Kanani H, McMullan T. Use of mini-monoka stents for punctal/canalicular stenosis. ***Br J Ophthalmol*** 2012; 96: 671-673.
47. Malet T, Challier B, David N, Bertrand A, George JL. Clinical and scintigraphic comparison of silicone and polyvinylpyrrolidone coated silicone perforated plugs. ***Br J Ophthalmol*** 1998; 82: 1416-1419.
48. Bohlman H. Perforated punctal plug in the treatment of partial punctal stenosis. ***Optometry*** 2003; 74: 524-528.
49. Konuk O, Urgancioglu B, Unal M. Long-term success rate of perforated punctal plugs in the management of acquired punctal stenosis. ***Ophthal Plast Reconstr Surg*** 2008; 24: 399-402.
50. Murube J, Murube E. Treatment of dry eye by blocking the lacrimal canaliculi. ***Surv Ophthalmol*** 1996; 40: 463-480.
51. Balaram M, Schaumberg DA, Dana MR. Efficacy and tolerability outcomes after punctal occlusion with silicone plugs in dry eye syndrome. ***Am J Ophthalmol*** 2001; 131: 30-36.
52. Tai MC, Cosar CB, Cohen EJ, Rapuano CJ, Laibson PR. The clinical efficacy of silicone punctal plug therapy. ***Cornea*** 2002; 21: 135-139.
53. Fayet B, Bernard JA, Ammar J, Taylor Y, Bati E, Hurbli T, et al. Complications of punctum plug in the symptomatic treatment of dry eye. ***J Fr Ophtalmol*** 1990; 13: 135-142.
54. Fayet B, Benabderrazik S, Bernard JA, Deligne L, Hürbli T, D'Hermies F, et al. Canalicular stenoses complicating the insertion of lacrimal plugs. Incidence and mechanisms. ***J Fr Ophtalmol*** 1992; 15: 25-33.
55. Boldin I, Klein A, Haller-Schober EM, Horwath-Winter J. Long-term follow-up of punctal and proximal canalicular stenoses after silicone punctal plug treatment in dry eye patients. ***Am J Ophthalmol*** 2008; 146: 968-972.
56. Carrim ZI, Liolios VI, Vize CJ. Punctoplasty with a Kelly punch. ***Ophthal Plast Reconstr Surg*** 2011; 27: 397-398.
57. Edelstein JP, Reiss G. Introducing the Reiss punctal punch. ***Arch Ophthalmol*** 1991; 109: 1310.
58. Edelstein J, Reiss G. The wedge punctoplasty for treatment of punctal stenosis. ***Ophthalmic Surg*** 1992; 23: 818-821.
59. Offutt WN 4th, Cowen DE. Stenotic puncta: microsurgical punctoplasty. ***Ophthal Plast Reconstr Surg*** 1993; 9: 201-205.
60. Awan KJ. Laser punctoplasty for the treatment of punctal stenosis. ***Am J Ophthalmol*** 1985; 100: 341-342.
61. Fein W. Cautery applications to relieve punctal stenosis. ***Arch Ophthalmol*** 1977; 95: 145-146.
62. Fraser CE, Petrakos P, Lelli GJ Jr. Adjunctive re-dilation for early cicatrization after punctoplasty. ***Orbit*** 2012; 31: 313-315.
63. Ahn HB, Seo JW, Roh MS, Jeong WJ, Park WC, Rho SH. Canaliculitis with a papilloma-like mass caused by a temporary punctal plug. ***Ophthal Plast Reconstr Surg*** 2009; 25: 413-414.
64. Han JH, Park JW, Kim SC. Reactive lymphoid hyperplasia of lacrimal canaliculus caused by a silicone plug. ***Ophthal Plast Reconstr Surg*** 2012; 28: e138-e140.
65. de Jong D, Vasmel WL, de Boer JP, Verhave G, Barbé E, Casparie MK, et al. Anaplastic large-cell lymphoma in women with breast implants. ***JAMA*** 2008; 300: 2030-2035.
66. Murakata LA, Rangwala AF. Silicone lymphadenopathy with concomitant malignant lymphoma. ***J Rheumatol*** 1989; 16: 1480-1483.
67. Fukuhara J, Kase S, Ishijima K, Noda M, Ishida S. Conjunctival lymphoproliferative disorder. ***Ophthalmology*** 2011; 118: 423.
68. Shahid H, Sandhu A, Keenan T, Pearson A. Factors affecting outcome of punctoplasty surgery: a review of 205 cases. ***Br J Ophthalmol*** 2008; 92: 1689-1692.
69. Billing K, Karagiannis A, Selva D. Punctal-canalicular stenosis associated with mitomycin-C for corneal epithelial dysplasia. ***Am J Ophthalmol*** 2003; 136: 746-747.
70. Kopp ED, Seregard S. Epiphora as a side effect of topical mitomycin C. ***Br J Ophthalmol*** 2004; 88: 1422-1424.