Eyedrop Instillation Techniques, Difficulties, and Currently Available Solutions: A Literature Review

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Abstract

Purpose: To review current eyedrop instillation techniques, common difficulties faced by patients instilling eyedrops, available eyedrop assistive devices, and patient education regarding eyedrop instillation.

Methods: PubMed, Embase, and Google Scholar were searched from conception until June 2022 for articles on eyedrop instillation difficulties, techniques, tools, and patient education.

Results: Instillation involves pulling down the lower eyelids and placing drops on the corneal surface or conjunctival fornix, followed by closing of the eyelids for about 1 min. Examples of techniques include eyelid closure and nasolacrimal obstruction techniques. Patients encounter many difficulties when administering eyedrops, including but not limited to poor visibility, squeezing the dropper bottle, aiming the bottle, and accidentally blinking. However, devices are available that assist with aim and dropper compression-force reduction in eyedrop instillation. These can be particularly useful in patient demographics with diminished manual dexterity or the ability to generate force from their fingers. Furthermore, despite patient education in eyedrop instillation not being a common practice, it has been found that adequate patient education can lead to significant improvement in eyedrop instillation technique.

Conclusions: While many factors are associated with poor eyedrop instillation technique, there are many solutions available including assistive devices and proper instillation education.

Keywords: Eyedrop administration, Eyedrop difficulties, Eyedrop instillation, Eyedrop technique

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Introduction

Eyedrop medications are crucial for the treatment and management of several conditions. Beyond patient compliance, the drop instillation technique is a significant variable that affects the efficacy of these medications.[1] This can lead to the progression in the severity of their condition and prevent patients from being able to manage their care from home, likely increasing reliance on limited emergency care resources.[2] Many patients report difficulties with instilling eyedrops, which include positioning of the dropper bottle, the force required to produce a drop from the bottle, or trying to avoid accidental contamination of the dropper.[3] These difficulties can be alleviated with the use of assistive devices that can help with aim or force generation.[4] Furthermore, education can drastically improve a patient's ability to administer eyedrops.[5] However, it has been shown that patients are unlikely to receive sufficient explanations on proper eyedrop administration.[6] Currently, there is limited literature about the difficulties experienced by patients surrounding eyedrop instillation and the possible available solutions. The purpose of this literature review is to summarize the current eyedrop

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instillation techniques, common difficulties faced by patients, available assistive devices, and patient education regarding eyedrop instillation.

Methods

We included publications that described patient eyedrop instillation, with a particular focus on patients' techniques, difficulties, and possible solutions. We also included articles about patients education in eyedrop instillation and included both qualitative and quantitative articles. The databases searched include PubMed, Embase, and Google Scholar from conception until June 2022. Studies were excluded if they were not in English, not peer-reviewed, or if the study's focus was not surrounding eyedrop instillation. Data extraction was performed using a structured document based on the following categories: Techniques for eyedrop instillation, difficulties faced by patients in eyedrop instillation, current options to assist with eyedrop instillation, and patient education in eyedrop administration.

Results

Techniques for eyedrop instillation

There is limited literature describing common patients' techniques for self-administering eyedrops despite technique being a major factor in medication efficacy. Even when the medication and dosage are kept static, improper instillation techniques can lead to significant differences in outcomes and therapeutic benefits in common eye pathologies such as glaucoma.[7] Optimal technique involves pulling the lower eyelid inferiorly with one or two fingers while placing the drops of solution onto the conjunctival fornix or directly to the corneal surface.[2] This should be done without touching the tip of the bottle to the lashes, eyelid, or eye surface.[2] Ocular contact time, or the time the topical medication spends on the eye surface, is directly related to the medication's efficacy. This can be maximized by grasping the lower eyelid near the margin with the thumb and index finger and pulling outward and closing the eye for approximately 1 min postapplication.[8] Furthermore, it is crucial to avoid contamination of the bottle, which can be a source of ocular irritation, inflammation, and infection.[9] Other elements of good technique involve proper hand hygiene and shaking the eyedrop bottle before application.[10] One study showed that 69% of postoperative cataract surgery patients self-reported always washing their hands before instilling their eyedrops.[11] However, to our knowledge, there is no further literature investigating patient hand hygiene in the context of eyedrop instillation.

Studies have attempted to describe the practical aspects of patients' drop administration technique to identify potential steps of concern and illustrate the large variations in practice. For example, a 2007 study conducted by Tsai *et al*. summarized the patterns of eyedrop administration. They found that most patients administer eyedrops either standing (36.4%) or sitting (37.8%).[8] With respect to technique, they found most patients use both hands to apply an eyedrop, with the most common practice being to use the right hand to hold the dropper bottle (87.4%) and to use fingers to hold open the eyelids (79.7%).[8]

An alternative method often used is the closed-eye technique. This involves instilling one eyedrop into the nasal corner of the closed eyelid. In this technique, the patient then opens their eye to allow the drop to flow into the eye.[10] This technique can serve as an easier alternative for individuals who struggle with tremors or other motor impairments.[12] One study explored a similar technique in children which involved placing eyedrops on the inner canthus with the subject lying supine and eyes tightly closed. In this technique, the patient proceeds to their eyes to allow the eyedrops to make contact with the eye.[13] It was shown that although the instilled solution makes contact with the eye using this technique, it does so to a lesser extent compared to conventional eyedrop installation. However, this technique can still be used in children who are less likely to cooperate with the conventional eyedrop application technique.[13] These studies demonstrate that there are alternative techniques available to best suit the needs of particular patient populations.

In Berggren's study, there were only small intra-subject differences when eyedrops were instilled using different application techniques including nasolacrimal obstruction, eyelid closure, and a combination of both. Nasolacrimal obstruction is a technique which consists of applying the eyedrops, then closing the eye and pressing a finger to digitally compress the nasal corner of the eye for approximately 1 min. This is meant to obstruct the nasolacrimal duct, thus reducing the elimination of the drug through the nasolacrimal system. The eyelid closure technique consists of the patient simply closing their eye postinstillation for about 1 min. This study suggests that different application techniques of eyedrops are less important in practice than originally assumed.[14] However, it is also important to consider the individual differences in pharmacological response even when the same application technique is applied. For example, Berggren's study found intra-subject differences in a group of healthy young females, even when the application and amount of pilocarpine ointment remained the same.[14]

Furthermore, for patients prescribed multiple eyedrop medications, it is generally recommended that patients wait approximately 5 min between eyedrop administration of different medications.[15] This ensures the second drop does not dilute the first and avoids accelerated nasolacrimal drainage, which may cause systemic adverse effects.[16] This was supported by a study that investigated the effects of various time intervals between administering two different dilating eyedrops. They concluded that there is a 5.6% pupil surface gain when waiting 5 min between instillation compared to when administering them together.[17] However, another study investigated the concurrent usage of tropicamide 0.125% and phenylephrine 2.5% eyedrops. They determined that there was no therapeutic benefit to waiting 10 min between instillation compared to administering them at the same time.[18] Ultimately, further investigation is required to determine the appropriate time to wait between administering different eyedrop medications.

Difficulties faced by patients in eyedrop instillation

Commonly encountered difficulties with eyedrop use and compliance should be explored to identify potential areas of intervention. For many patients, the correct dosage is often not being delivered to the ocular surface, thus resulting in ineffective treatment response. In fact, one study determined that only 39% of patients with glaucoma administer eyedrops using proper technique.[2] It has been shown that getting medication into the eye, touching the tip of the bottle to the eye or face, and wasting drops were some of the most common elements of difficulty.[19] As noted in one study, only 9% of glaucoma patients using eyedrops are able to properly self-administer them.[20] The study also showed that 34% administered eyedrops onto the cheek or eyelid and 76% of patients touched their eye or the tissue surrounding their eye with the tip of the bottle.[20] In a questionnaire for patients, it was determined that the most frequently encountered difficulty was directing the eyedrop bottle (36%).[3] Other common difficulties included squeezing the bottle (20%), accidentally blinking (12%), and poor visibility of the eye dropper (13%).[3] Upon further discussion with patients, it became clear that a lack of confidence in their abilities and fear of accidentally physically making contact with their eye using the dropper was causing them to hold the dropper further from their eye, thus increasing the difficulty in aiming. It was further determined that these difficulties result in increased levels of noncompliance with appropriate medication regimens. In particular, it was found that only 64% of patients were administering their drops as instructed by their physician.[3]

Age, education level, hand–eye coordination, and other physical and psychological factors likely influence eyedrop instillation difficulty. For example, one study found an association between poor manual dexterity or functional impairment and poor eyedrop technique.[5] In addition, elderly patients with diminished strength and those with musculoskeletal issues or visual impairment are more prone to committing mistakes when administering ocular medication.[2] Furthermore, cognitive barriers such as forgetfulness and confusion along with poor self-efficacy, limited knowledge about one's disease, and medication costs have also all been cited as barriers to compliance, with 61% of patients facing multiple barriers.[21]

Current options to assist with eyedrop instillation

There are commercial devices available to help with bottle squeezing and to enhance the aim for eyedrop installation.[4] Some current options on the market include Easidrop® (Quoteforce, UK), which is a device that attaches to a standard eyedrop bottle, sits within the orbit and aids in aiming while keeping the bottle's tip clear of the eye.[22] Eyedrop® (Vanguard Design, São Paulo, Brazil) is a plastic device that lies on the orbit and holds the bottle. The device aids patients in keeping their eyes open, improving aim, and reducing tip contamination.[22] Eyot® (Spruyt Hillen, IJsselstein, Netherlands) is a drop guider that helps in appropriate drop instillation.[22] In addition, in a crossover study by Nordmann *et al.*, Xal-Ease® delivery device, a device which helps patients correctly position their eyedrops, reduced the number of patients who needed further assistance instilling their drops, touched their eye with the bottle tip, and frequently or always missed their eye with the drop.[23] Strungaru *et al*. also investigated a more simple solution called the mirror-hat delivery system, which fitted a magnifying glass to the brim of a common baseball cap. This method lowered the number of patients who touched the eye with the bottle from 37% to 13%, but there was no improvement in instilling exactly one drop or aiming in the eye.[24]

Aim assist

Gomes *et al*. conducted a prospective study of patients considered inexperienced in eyedrop instillation and compared the instillation of eyedrops with and without Xal-Ease® delivery device.[25] The results of the study showed that both approaches had the same overall percentage of effective instillation (with or without the device).[25] The bottle tip contacted the eye or periocular tissues in 35% of patients without the device, compared to 0% of patients with the Xal-Ease®. Fifty-seven percentage of patients who used the Xal-Ease® device required more than one try, compared to 26% of patients who did not. Overall the study included that 39% of patients favored conventional instillation, whereas 61% preferred device usage.[25] Xal-Ease® successfully reduced mechanical contact of the bottle tip.[25] However, Xal-Ease® did not assist unskilled individuals in administering fewer drops or increase accuracy, suggesting that further training may be required to acquire a successful eyedrop administration method with the device.[25] Junqueira *et al*. carried out a prospective trial with consecutive glaucoma patients and healthy volunteers, and the Eyedrop® delivery device was made available to all participants for usage in one eye.[24] When compared to conventional instillation, Eyedrop® got a higher subjective rating for ease of instillation of hypotensive eyedrops, particularly in individuals with no prior experience with eyedrops.[26] The use of the device resulted in no loss of hypotensive effect or an increase in the frequency of adverse effects.[26] Given the current evidence, assistive devices are effective in improving eyedrop instillation success rates; however, other factors such as education are important in improving success rates.[26] In general, the published trials have a limited sample size, a short follow-up time, and only assessed one drug (monotherapy). Furthermore, there is the possibility of positive bias in favor of the device, since the individual stimulus provided by the introduction of new equipment may lead to a higher commitment to medicine usage, regardless of the effectiveness of the applicator itself.[26]

Force reduction

Several aid devices address difficulties associated with the use of eyedrops such as the force required to squeeze the bottle and positioning of the bottle. Connor and Severn's study explored the force requirements of topical ocular medicines and whether aids truly reduce the finger strength required to deliver an eyedrop.[27] Interestingly, they noted variability in force requirements between different topical medicines, which significantly influences patient compliance and suggests that particular medications might be more beneficial due to easy squeezability.[27] They also looked at several compliance aids such as Xalaease®, Eyot®, Opticare®, and Opticare artho® and observed that they actually increased the force requirements, but these results may be misleading and concealing other beneficial effects such as altering the patient's grip to a position that allows force to be applied more easily.[27] Another dosing aid that was explored is the Travatan Dosing Aid® (TDA), which is a monitoring device that was evaluated by Cronin *et al*. for its accuracy in recording and dispensing eyedrops.[28] They found that this monitoring device accurately recorded the administration of eyedrops without compromising on ease of use. It delivered 99% of the drug regardless of the quantity remaining in the bottle but required specific conditions to record administration such as full depression of the TDA lever without prolongation.[28] Monitoring devices such as the TDA can be very helpful in informing practitioners of patient compliance as long as the patient is well informed on how to use the device properly to avoid misrepresentation of compliance.[28] Another device that is particularly helpful in patients with dexterity issues is the AutoSqueeze bottle aid (Owen Mumford, Georgia, USA) because of its ergonomic grip. It was found that about 75% of patients would consider using it long-term.[29] One challenge associated with improved eyedrop instillation outcomes is patient education which requires both time and financial resources which in a busy clinic, may not be practical or feasible.[7,29] In addition, practical application barriers such as fear, poor hand–eye coordination, or other physical or psychological factors that may impact the patients' overall performance while using the aforementioned assistive devices.[29]

Patient education in eyedrop administration

Several studies have shown improvement in technique following education sessions, suggesting that clear instructions on the instillation technique should be given to all patients prescribed regular eyedrops.[5] In fact, one study found that even video instructions showed marked improvement in self-efficacy and technique, making them a viable education method if personnel are not available.[30] Despite instructions to patients being associated with better technique, patients rarely receive explanations on how to instill eyedrops properly. Notably, many patients receive education from nonophthalmologist practitioners including technicians, nurses, and pharmacists.[6,7,31] Furthermore, many patients may resort to the internet if they need clarification about eyedrop instillation.[7]

In addition, Al-Busaidi *et al*. suggested that it may be beneficial to directly observe patients applying medications and provide immediate feedback and encouragement.[7] An *et al*. suggested that patient education through direct instruction improves eyedrop instillation by showing a better performance score compared to patients who did not receive instructions (odds ratio, 11.99; $P = 0.011$).[11] A randomized control trial by Davis *et al*. aimed to assess the efficacy of an online video intervention in enhancing glaucoma patients' self-efficacy and eyedrop administration technique.[30] The intervention group viewed a 4-min Meducation® eyedrop technique video, while the control group watched a nutrition film. The study concluded that an online teaching film can greatly enhance the glaucoma eyedrop technique in the short term. After controlling for baseline technique, intervention participants performed 0.75 steps better than controls immediately after the film and 0.63 eyedrop technique steps better after 1 month.[30] This demonstrates that the video's favorable effect was mostly sustained at least until the 1-month time point. Donnelly approached patient education from a broader lens.[32] They concluded that to ensure patient adherence and instillation success: Education programs should ensure that patients understand the objectives of medication, give encouragement and comfort to the patient as they are learning the method, and ensure the patient learns the motor skills of drop instillation.[3] Lazcano-Gomez *et al*. demonstrated that even a single education session is efficacious. With proper instruction, the percentage of patients that instilled just one drop on the eye to increase from 67% to 82% and the incidence of touching the bottle to the patient's ocular adnexa decreased from 64% to 29%.[2]

Discussion

Proper eyedrop instillation is vital to maximize the therapeutic benefits of ocular medications. Although medication compliance is often seen as patients' responsibility, compliance can be increased by providing patients with more guidance regarding proper instillation techniques. Many studies exploring the role of patient education demonstrated that instructions provided to patients through various methods ranging from videos to live one-on-one instructions had a positive impact on eye instillation technique. However, patients also struggle with the administration of ocular medications for motor difficulties and visual impairment. For these patients, assistance devices available on the market may be beneficial for correcting the instillation technique. The pros of assistive devices include decrease in mechanical contact of the tip of the bottle, decrease in bottle tip contamination, and improved subjective response regarding ease of instillation. Some concerns with assistive devices are training, where inexperienced patients still struggle. The results of this review suggest that although there are many factors associated with poor instillation techniques, solutions to these obstacles are available. This information can be used to identify gaps in patient care to increase benefit from ocular medications, and thus allow patients to better manage their care in a field where self-administering medications are crucial.

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There are no conflicts of interest.

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