



Ophthalmic regional anesthesia techniques

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ABSTRACT

There is substantial national and international variation in the conduct of anesthesia for ophthalmic surgical procedures. Ophthalmic regional anesthetic techniques include traditional needle-based blocks, such as intraconal or extraconal injections; sub-Tenon's blocks which can be accomplished with needles, but are more commonly performed with blunt cannulae; and topical anesthesia. Needle-based techniques are generally safe although rare, serious sight- and life-threatening complications may occur. In recent years, a renewed interest in sub-Tenon's and topical anesthesia has emerged. Currently there is no absolutely safe ophthalmic regional block. It is essential that those who are involved in the care of ophthalmic patients have a thorough knowledge of the approaches employed and their associated risks and benefits. This review article outlines the relevant anatomy, commonly used techniques and their safe performance.

Key words: Ophthalmology - Nerve block - Anesthesia - Orbit - Eye.

Ophthalmic surgery dates back to prehistoric times when early medicine-men, using little more than sharpened sticks, would "couch" cataracts from their patients' eyes. By the early 19th century, sophisticated cataract surgical techniques were in place, but anesthetic modalities were still limited to little more than heavy restraints (Figure 1).¹ The introduction of general anesthesia in the mid-18 hundreds allowed for painless eye surgery; however, the need for the anesthetist to be near the airway, and hence, the eyes, as well as the side-effects of ether, limited its routine adoption. In 1884, Koller demonstrated that cocaine could be used as an effective topical anesthetic to abate the pain associated with ophthalmic surgery.² Shortly thereafter, Knapp delineated techniques of injecting cocaine within the orbit in order to achieve profound analgesia and akinesia of the globe.³ In the same year, Turnbull reported a method of achieving oph-

thalmic analgesia by instilling local anesthetic in the episcleral space.⁴ By the 20th century, a variety of needle-based conduction anesthesia techniques were elucidated, particularly by Atkinson, who popularized the term retrobulbar anesthesia.⁵ Needle-based injection anesthesia remained the mainstay of ophthalmic anesthesia for many decades, until the recent resurgence of interest in cannula-based sub-Tenon's blocks and topical anesthesia.⁶

There is substantial national and international variation in the conduct of anesthesia for ophthalmic surgical procedures.^{6,7} Cataract surgery is the commonest ophthalmic surgical procedure and local anesthetic techniques are first evaluated in these patients. Anesthesia techniques can be broadly divided into two groups: those block motor function of the extraocular muscles, and thus render the eye akinetic, and those that do not affect globe motility. Akinetic anesthesia of

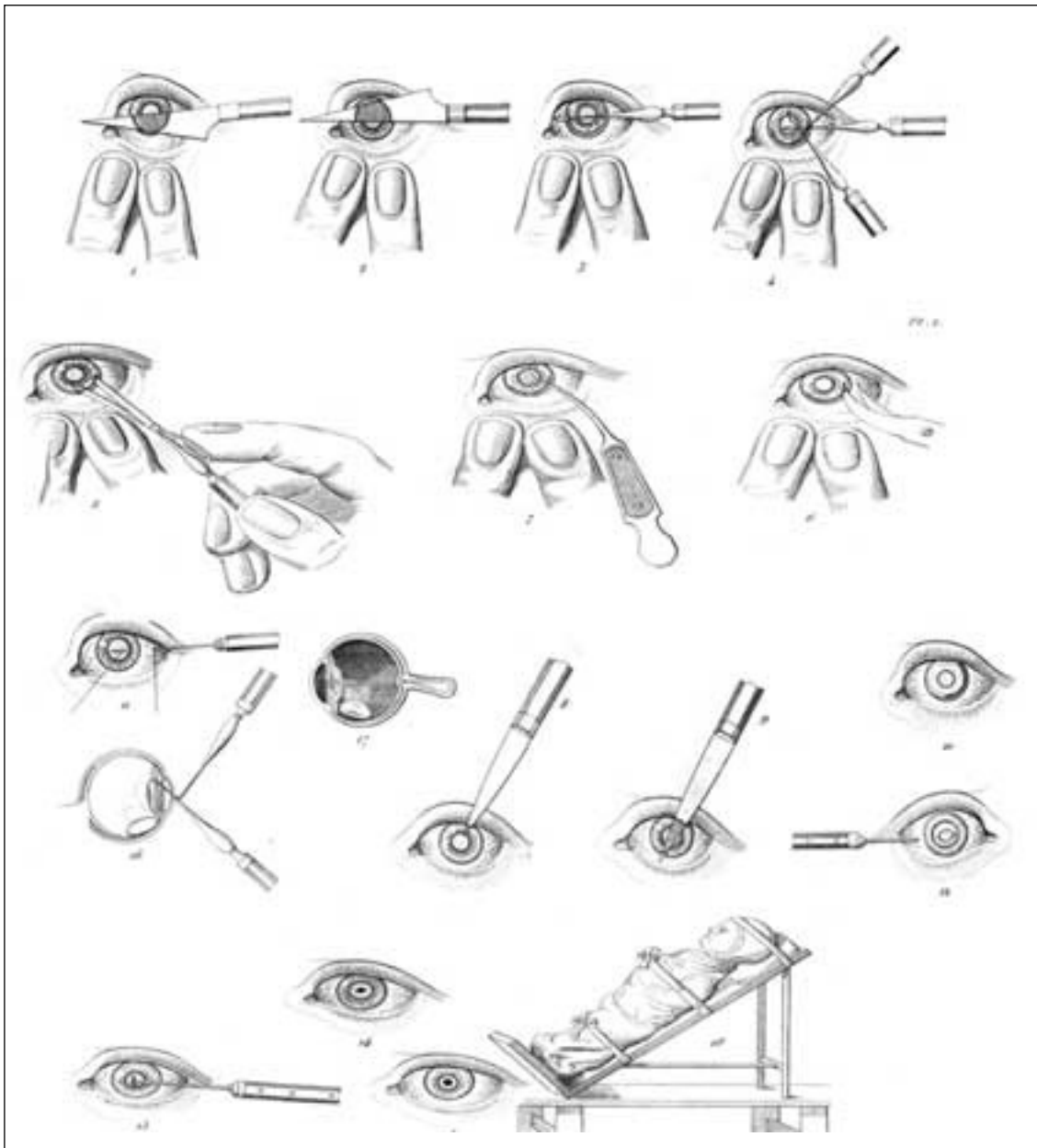


Figure 1.—By 1837, cataract surgical techniques were quite sophisticated; but with local and general anesthetics yet to be discovered, most patients required moderate restraint in order to tolerate the procedure. [Modified from Carron du Villards ¹].

the eye can be accomplished with needle injection of local anesthetics in or around the muscle cone or by instilling local anesthetic under Tenon's capsule using either a cannula or needle. General anesthesia also induces globe akinesia. Kinetic analgesia is accomplished with topical application of local anesthetic drops or gels and by intra-

cameral injection of preservative-free local anesthetics.

Topical ophthalmic anesthesia

Topical anesthesia offers the advantage that it is quick, simple and non-invasive. Immediate useful

vision is provided postoperatively. It is suitable for uncomplicated brief procedures by experienced ophthalmologists in selected cooperative patients. Topical anesthesia may be appropriate for some procedures on monocular patients, who can experience anxiety due to postoperative amaurosis of their functional eye following akinetic blocks. Additionally, patients with significant bleeding diathesis or profoundly abnormal globe/orbit features may be candidates for this anesthetic modality.

Although akinesia of the eye is not essential for modern cataract surgery, patient discomfort, excessive eye movement, photophobia, and blepharospasm can make the topical anesthesia experience untenable for patient and surgeon alike. Compensating for this scenario *via* over-sedation may precipitate patient movement and dire consequences.⁸ On the other hand, minimal sedation may lead to the need for ample “vocal local”.⁹ Similarly, topical anesthesia may be contraindicated in patients with small pupils who may require significant iris manipulation or those who need larger incisions.

Topical analgesia can be obtained with local anesthetic ophthalmic drops or gels.¹⁰ Higher drug concentrations in the anterior chamber occur with anesthetic gels than with equivalent doses of drops and may produce superior surface analgesia.¹¹ There are some concerns that use of gel-based topical anesthetics may enhance the likelihood of postoperative endophthalmitis, because they may act as a barrier to antiseptic agents. Therefore, it may be prudent to apply povidone-iodine prior to the anesthetic gel, taking care to instill anesthetic drops before the use of the caustic bactericidal prep (Figure 2). As corneal toxicity may be more likely with direct application of 10% povidone-iodine, a 5% solution may be more ideal; however, diluted antiseptics may have attenuated bactericidal effect.^{12, 13}

Intracameral injection of 0.1-0.2 cc of 1% preservative-free lidocaine into the anterior chamber can be used to supplement topical analgesia, but may have toxic effects on the corneal endothelium.¹⁴ Additionally, sedative-hypnotics may be indicated during the more stimulating portions of surgery, such as with corneal incision, iris manipulation, suturing, or during maneuvers that result in acute change in intraocular pressure.

Intraconal and extraconal ophthalmic anesthesia

Ophthalmic regional anesthetic blocks provide a practical means to achieve analgesia and akinesia of the globe. Many ophthalmic surgeons prefer the operating milieu of an immobile eye and the reassurance of suppression of the oculocardiac reflex. Patients may prefer regional anesthesia as, aside from intraoperative analgesia, it provides postoperative pain relief.¹⁵ Additionally, conduction anesthesia may be a suitable alternative to general anesthesia for selected patients with open globe injuries.^{16, 17}

The nomenclature used for describing needle-based ophthalmic regional anesthesia is controversial. Early in the 20th century, Atkinson coined the term, “retrobulbar block”, to describe his technique of orbital anesthesia that situates a needle’s tip behind (retro-) the globe (-bulbar) (Figure 3).⁵ As newer approaches developed, attempts at modifying the terminology resulted in terms such as peribulbar and extraocular, which provide little indication of needle position.^{18, 19}

The key differences in needle-based ophthalmic regional anesthesia approaches are in the insertion site and the depth and angulations of needle placement. The four extraocular rectus muscles, beginning at their origin at the Annulus of Zinn at the apex of the orbit and extending anteriorly to their insertions into the globe, describe a compartment known of as the orbital muscle cone. Newer nomenclature attempts to delineate anatomic positioning of the needle, based upon the relationship to this muscle cone.²⁰ The classic retrobulbar block is achieved by inferotemporal placement of an acutely angled needle deep within the orbit, such that the needle tip is positioned inside of the muscular cone (Figure 4).⁵ This cone was once thought to be a discrete compartment similar to the brachial plexus sheath; however, cadaveric and computed tomography (CT) studies have clearly demonstrated the ease of diffusion of injected materials between the intraconal and extraconal compartments.^{21, 22} Thus, local anesthetics injected outside of the muscle cone eventually spread into the intraconal space resulting in ocular anesthesia. In contrast to the intraconal (retrobulbar) block, an extraconal (peribulbar) block needle is placed shal-

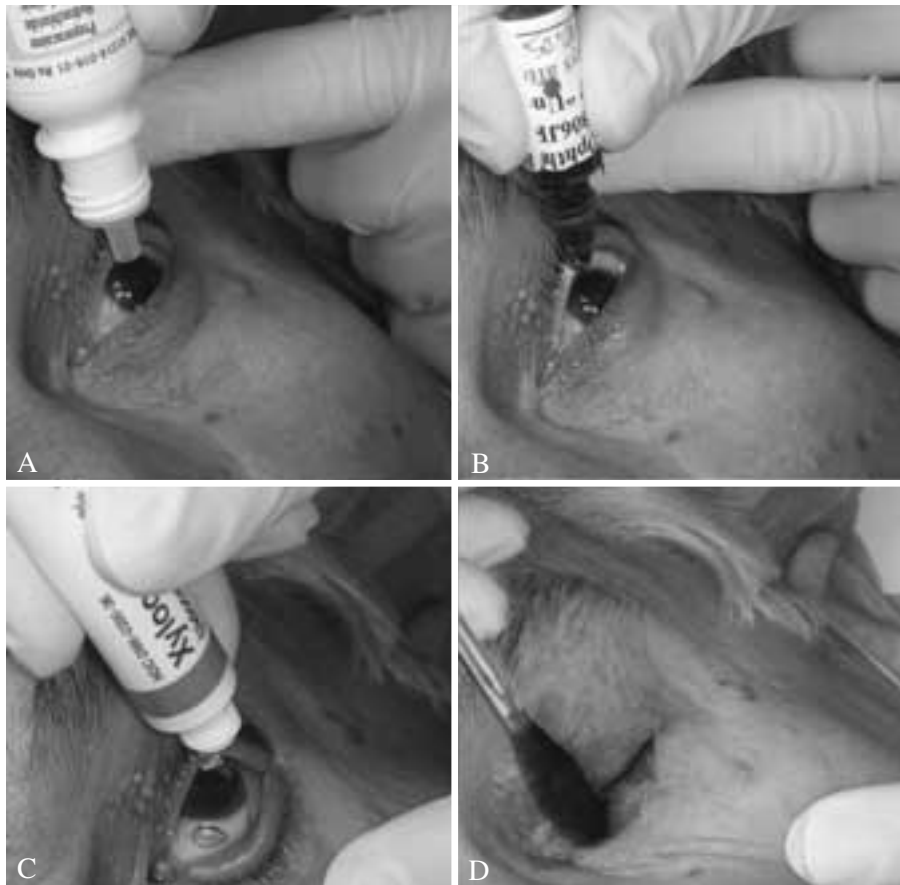


Figure 2.—Topical anesthesia. A) Topical drops followed by B) povidone-iodine prior to C) topical anesthetic gel, then D) eyelid antiseptic.

lowly and directed with minimal angulation along the floor of the orbit (essentially parallel to the globe) (Figure 5). Extraconal block is theoretically safer as the needle tip is not directed toward the apex of the orbit where the optic nerve, cranial nerves, major orbital vasculature, and muscles are densely associated, but toward the greater wing of the sphenoid bone, an area with comparatively few structures.

Intraconal ocular injection provides quick onset of profound sensory and motor blocks with minimal volume of local anesthetic, since these agents are placed immediately adjacent to the ciliary ganglion, optic nerve, and majority of orbital cranial nerves. Extraconal injection places local anesthetics at greater distance from key nerves, requiring time for diffusion of agents, thus mandating larg-

er volumes and longer latency of onset. Early descriptions of extraconal blocks suggested multiple injections were required to achieve adequate anesthesia; however, local anesthetics will spread throughout the orbit given sufficient time, such that a single high volume block will establish anesthesia without the risk that additional injections incur (Figure 6).^{23, 24} Diffusion of the higher volume extraconal local anesthetic through the orbit provides additional advantage of eyelid akinesia and suppression of the patient's ability to squeeze the eye shut. In contrast, low volume intraconal injection requires a separate block of the branches of the facial nerve supplying the orbicularis oculi if suppression of lid squeezing is deemed necessary, such as in the case of blepharospasm after insertion of a lid speculum, corneal transplantation,

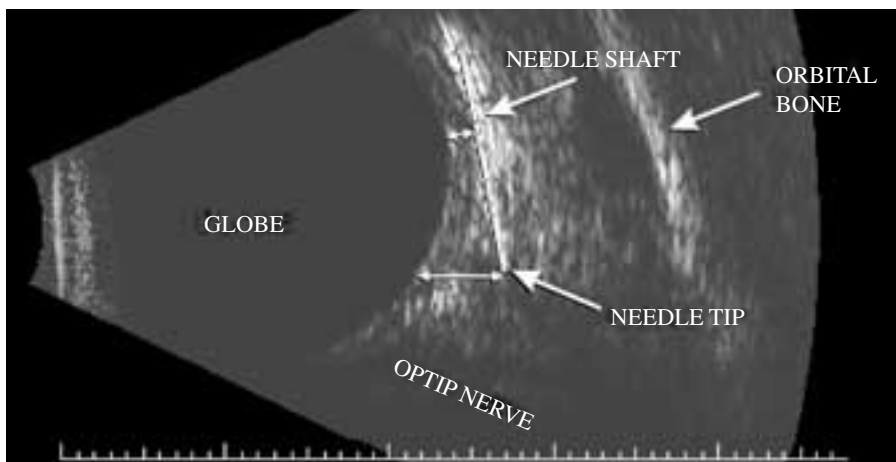


Figure 3.—Ultrasound of needle-based ophthalmic anesthetic. Technically, any block that places local anesthetic behind the equatorial margin of the globe can be deemed, “retrobulbar”.

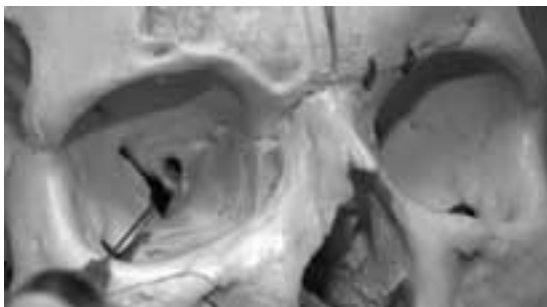


Figure 4.—A conventional intraconal block is acutely angled towards the apex of the orbit.

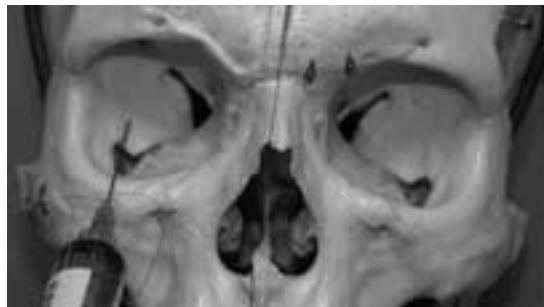


Figure 5.—An extraconal block needle is placed more shallowly and minimally angled. It parallels the axis of the globe and is directed towards the greater wing of the sphenoid bone.

or repair of traumatic globe injury *via* regional anesthesia.

Needle insertion sites have been described for a variety of locations around the globe. The traditional entry point for both intraconal and extraconal blocks has been at a plumb-line drawn inferiorly from the lateral limbal margin of the pupil to a point situated approximately 2/3 of the way laterally along the inferior orbital rim. A re-evaluation of this locus occurred subsequent to an abrupt increase in the reported incidence of restrictive strabismus following a shortage of hyaluronidase in the 1990's.²⁵ Theoretically, without the beneficial spreading effect of hyaluronidase, loculation of local anesthetic injected within the thin body of an extraocular muscle precipitated prolonged muscle injury, scarring, and development of postoperative strabismus.²⁶ One can avoid the

inferior rectus and inferior oblique muscles by relocating the insertion point of the needle more laterally along the inferotemporal margin (Figure 7).²⁷

Primary anesthetic technique or a supplementation of inadequate anesthesia by injection into the superior orbit is a commonly accepted technique. Access into this area is limited as the globe tends to be positioned closer to the roof of the orbit than the floor, thus exposing the eye to risk of globe penetration.^{27, 28} The superior orbit's osteology is less acutely angled such that there is shorter distance to reach the deep orbit, increasing the risk of complications if a needle is placed to similar depth as in the inferior orbit. Additionally, the superior oblique muscle and its trochlear apparatus can be damaged by superonasal needle placement. Finally, there is a preponderance of vasculature, including



Figure 6.—Crossconjunctival extraconal block. Given sufficient time, a single high volume block will establish anesthesia without the risk that additional injections incur.

the origins of the ophthalmic artery and vein, residing within the superior half of the orbit. Introduction of a needle in their vicinity increases the potential for significant hemorrhage.

The globe is aligned slightly more laterally than the midpoint of the orbit such that access on the nasal side can be achieved with needle entry medial to the caruncle or between the globe and caruncle along the fold of the semilunaris is termed as medial peribulbar block.^{29, 30} Medial peribulbar block is usually used as a supplementary injection, but some clinicians use this technique as a primary method of anesthesia, particularly in patients with longer axial length. Penetration of the lamina papyracea into the ethmoid sinus, globe puncture, and deep orbital injection are potential complications.

Needle architecture, including length, shape, gauge, and bevel profile affect both the quality and safety profile of ophthalmic anesthesia. The tip of a traditional 38 mm (1.5 inch) needle, placed for a conventional intraconal block, can reach critical structures in the densely packed orbital apex in up to 20% of adult patients.³¹ In some cases, the tip may even reach the optic foramen. Shorter needles, 31 mm (1.25 inches) or less are more optimal.³²

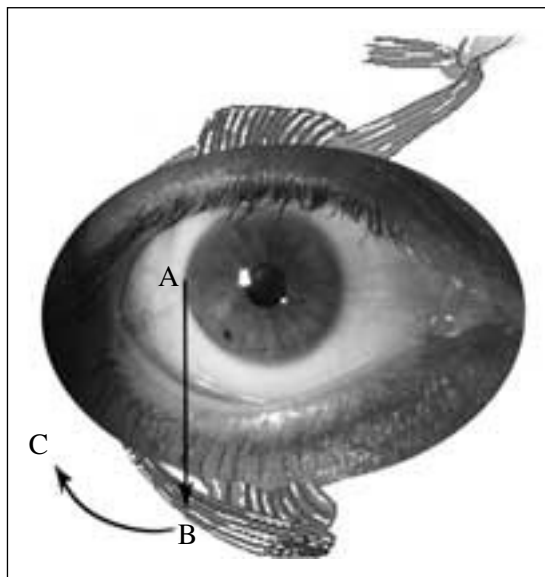


Figure 7.—The traditional entry point intraconal and extraconal blocks is at a plumb-line drawn inferiorly from the lateral limbal margin (A) to a point approximately 2/3 of the way laterally along the orbital rim (B). Relocating the needle insertion site more laterally along the inferotemporal margin (C) avoids the inferior rectus and inferior oblique muscles.

The limitations of block nomenclature are evident when considering needle length. By definition, one distinguishes intraconal *versus* extraconal blocks based upon the depth and angulation of the presenting needle. An extraconal block is shallowly placed with minimal angulation, with a course nearly parallel to the globe. An intraconal block needle is angled more acutely and situated deeper within the orbit. As the pyramidal shaped orbit narrows approaching its apex, the rectus muscles come into direct contact with bone and the extraconal area becomes potential space.²⁷ Therefore, an “extraconal” block placed with a long needle, may truly be a minimally angled intraconal injection.²⁰

Ophthalmic regional anesthesia is typically accomplished with inexpensive straight needles. Customized commercially available curved or angled needles, intended to be wrapped around the globe, have been touted as a more elegant means to avoid iatrogenic eye injury.^{33, 34} Variability in ocular anatomy and block technique may complicate approximation of ultimate tip position within the orbit.³⁵

There is a significant debate as to optimal nee-

dle gauge and tip morphology. Fine-gauge needles with acutely-beveled sharp tips penetrate tissue more readily and are thus less painful on insertion. There may, however, be uncertainty as to final position of the tip within the orbit due to arcing of the needle shaft during placement. Additionally, sharp narrow needles provide diminished tactile feedback, therefore accruing a theoretical increased risk of globe puncture.³⁶ Larger gauge, blunt-tip needles require greater force in order to penetrate sclera such that globe movement in the course of the conduct of a block may be a sign of impending perforation and provide a signal to desist and re-assess.³⁷ Inadvertent globe puncture by wider-gauge, dull needles, however, tend to cause more severe retinal injury.³⁸

Risk factors that enhance potential for accidental needle penetration of the globe include increased optical axial length, recession of the eye, and limited operator experience.³⁹ Intraconal injection requires placement of an acutely angled needle deep within the orbit. If an eye's anterior-posterior distance is significantly longer than average, there is a greater risk of accidental injection of the posterior pole of the globe by steep angulation of the needle. A-P length is increased with myopia, staphylomata, and prior scleral buckle surgery.⁴⁰ An *in situ* scleral buckle deforms the globe, enlarging the axial length. A staphyloma is an aberrant out-pouched section of globe, typically located posteriorly at the nexus of eye wall and optic nerve. Ideally, confirmation of globe length (<26 mm) and shape (no staphyloma) can be accomplished if a preoperative ultrasound has been performed. Additionally, the surface anatomy should be assessed to determine the globe-orbit relationship as presence of marked globe recession may enhance risk of posterior pole puncture.

The ultimate location of the tip of an intraconal block needle is typically more proximate to the posterior pole of the globe than anticipated.⁴¹ The extraconal approach of shallower needle placement with minimal angulation may diminish the likelihood of encountering the globe's hind surface; however, inadvertent needle penetration can nonetheless occur at the globe's periphery (Figure 8). This risk is particularly enhanced if the eye is myopic, as globe dimensions increase in all axes with near-sightedness.⁴² Past reports of adverse

sequale by minimally trained anesthetists affirm that the potential for needle misadventure varies inversely with operator education and experience.^{36, 38, 43} Formal training *via* university or society programs (such as the Ophthalmic Anesthesia Society or the British Ophthalmic Anaesthesia Society) is encouraged.

In the classic Atkinson inferotemporal retrobulbar block, the patient was instructed to gaze upward and inward.^{5, 44} Using CT scan examination of cadaveric orbits, Unsold *et al.* demonstrated that this maneuver stretches the optic nerve proximate to the oncoming needle and fixes it such that it cannot freely be displaced when encountered.⁴⁵ Injection of local anesthetics along the optic nerve sheath can precipitate brainstem anesthesia with symptoms ranging from dysphagia, contralateral amaurosis, dysrhythmias, sedation, apnea, neurogenic syncope, or cardiac arrest.⁴⁶ Avoiding the deep orbit and requesting the patient maintain neutral gaze to preserve optic nerve laxity serve to minimize potential complications.⁴⁷

Sub-Tenon's ophthalmic anesthesia

Ophthalmic regional anesthesia can be obtained by instilling local anesthetics in the episcleral space below Tenon's capsule employing either needles or cannulae.⁴⁸ Use of cannulae may reduce or eliminate some of the rare adverse sequale associated with traditional needle-based blocks. While the basic technique was described over one hundred years ago, it has been re-popularized with modifications by Turnbull, Mein *et al.*, Stevens and Greenbaum.^{4, 49-51}

Tenon's capsule is a fascial layer of connective tissue that surrounds the globe and invests into the extraocular muscles (Figure 9). Anteriorly, it is fused to the conjunctiva a few millimeters posterior to the limbal margin. Behind the eye, it terminates at or near the optic nerve insertion into the globe. With increasing age, the posterior portion may degenerate and recede. The potential space between the rigid sclera and the capsule known as the sub-Tenon's or episcleral space contains a trabecular meshwork filled with lymphatic fluid that functions to provide a low-friction environment for smooth unimpeded excursion of the globe. Sensory

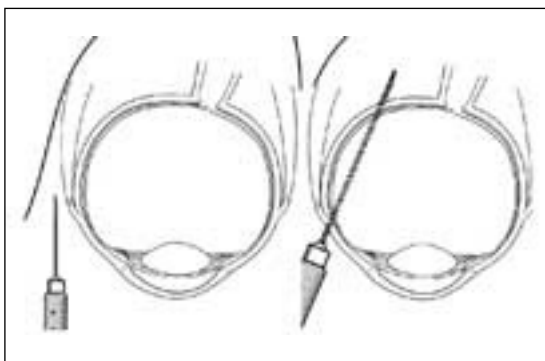


Figure 8.—Intraconal approach (right) may place the globe's posterior pole at risk for needle penetration. The extraconal approach (left) of shallow needle placement and minimal angulation may decrease potential of encountering the globe's hind surface; however, inadvertent needle penetration can nonetheless occur at the globe's periphery.

innervations in the form of short ciliary nerves from the ophthalmic branch of the trigeminal nerve penetrate the posterior capsule *en route* to the globe. Injection of local anesthetics under Tenon's capsule will thus produce analgesia.⁵² Amaurosis ensues when anesthetic bathes the anterior portion of the optic nerve.⁵³ Akinesia occurs due to blockade of motor nerve branches as they travel through the space on course to the extraocular muscles.⁵⁴

Needle-based sub-Tenon's block is accomplished by introducing a fine gauge needle in medial compartment by placing a needle lateral to caruncle and redirecting the tip of the needle medially and then advancing directly posteriorly to a depth of 10 to 15 mm.⁵⁵ Unlike cannula-based sub-Tenon's blocks, surgical dissection is not required. Nouvellon *et al.* has reported an acceptable safety profile in over 2 000 such procedures.⁵⁶

Cannula-based sub-Tenon's blocks omit use of a needle in favor of a blunt cannula, thus avoiding some of the potential complications associated with needle-based ophthalmic anesthesia techniques.⁴⁶ In order to obtain access to the episcleral space, conjunctival anesthesia with topical agents must first be assured. Dissection can be accomplished in any of the quadrants; however, an inferonasal approach is most commonly reported. After obtaining surface analgesia and instilling 5% povidone-iodine on the eye, the patient is asked to gaze in the direction diagonally oppo-

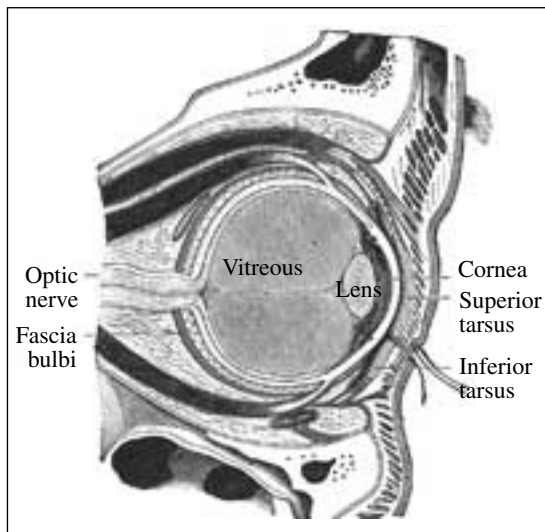


Figure 9.—Diagram showing Tenon's capsule with connective tissue bands traversing the sub-Tenon's space. [With kind permission from www.bartleby.com].

site from the intended incision site, in order to broadly expose the access area. The fascia is grasped with a toothless forceps approximately 3 to 5 mm from the limbal margin (Figure 10) and a small incision is made with blunt scissors. Adequate dissection is insured by visualization of the characteristic dull white sclera below Tenon's capsule. A blunt cannula (Figure 11) is inserted through the opening along the scleral curvature and local anesthetic is injected. Volumes of 3 to 5 cc are typical; however, use of as little as 1.5 cc upwards to 11 cc have been promulgated.^{51, 57, 58}

There are a variety of cannulae available.⁵⁹ They differ in their construction materials, flexibility, shape, and length. They may be straight, or alternatively contoured to conform to the globe. Some are tapered or have stops designed to limit depth of insertion and occlude the dissected opening in order to promote posterior flow of local anesthetic while attenuating anterograde leakage.⁶⁰ Metallic cannulae are rigid and offer ease of insertion. Plastic or silicon cannulae are pliable and may have less traumatic potential.⁶¹ Length varies from approximately 2.5 cm to the ultrashort, 0.6 cm, cannula.⁶² Ultimately, the selection of cannula depends upon availability and clinician preference.

Commonly encountered complications of sub-Tenon's anesthesia are mostly minor. These include



Figure 10.—Position of the globe during inferonasal approach of sub-Tenon's block dissection performed with forceps and scissors 5-8 mm away from the limbus (the patient is asked to look upwards and outwards).

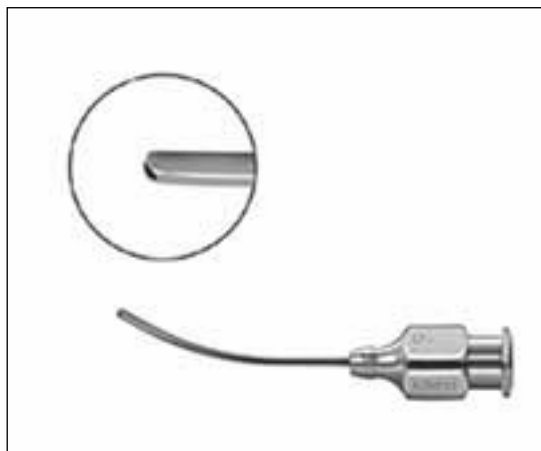


Figure 11.—A blunt posterior sub-Tenon's metal cannula 19 G (2.54 cm length).

pain upon injection, reflux of local anesthetic, chemosis, bleeding, and retained visual sensations.^{63, 64} Incidence varies widely in the literature.⁵⁹⁻⁶⁵ Visual analogue pain scores are typically low; however, outliers have been reported.^{50, 65, 66} Smaller cannulae may afford marginal benefit.⁵⁹ Anterograde reflux and loss of local anesthetics upon injection occurs if the dissection is oversized relative to the gauge of the cannula. Inadequate access into the episcleral space can also promote overspill and chemosis. The incidence of chemosis varies with volume of local anesthetic, dissection technique, and choice of cannula.^{50, 67} Shorter cannulae are associated with increased likelihood of conjunctival chemosis, up to 100% in some studies.⁶⁰ Conjunctival hemorrhages are common, with some studies also reporting up to 100% incidence.^{50, 60, 65} Occurrence can be reduced with careful dissection, use of handheld cautery, or application of topical epinephrine.^{51, 65, 68}

Sub-Tenon's anesthetics often produce good sensory analgesia, but may have variable degrees of motor blockade.^{65, 66} Akinesia improves with larger volumes of local anesthetic; however, complete akinesia with attenuation of superior oblique muscle and eyelid function may be difficult to achieve. As with traditional needle-based and topical ophthalmic anesthesia, some patients undergoing sub-Tenon's block may experience intraoperative visual sensations due to incomplete optic nerve blockade.^{69, 70} While the majority of such patients are not

disturbed by this phenomenon, up to 16% may deem it dysphoric and should be counseled appropriately.^{71, 72}

A number of major complications from sub-Tenon's blocks have been reported. These include significant orbital hemorrhage, globe perforation, orbital cellulitis, postoperative diplopia, optic neuropathy, pupillary/accommodation defects, retinovascular and choroidovascular occlusion, and central spread of local anesthetic with cardiopulmonary sequelae, among others.^{64, 72-80} These complications tend to be associated with use of longer, more rigid cannulae.⁶³ The likelihood of encountering these rare issues may be diminished with use of shorter, flexible cannulae; however, the incidence of common minor complications rises as length and rigidity falls.^{59, 60}

Conclusions

There have been a plethora of publications extolling high success rates and relative safety of various described ophthalmic regional anesthetic techniques including topical, needle based intraconal and extraconal blocks as well as needle or cannula based sub-Tenon's blocks. Every described technique has its own advantages and disadvantages and at present there is no absolutely safe technique to provide the ideal scenario of complete akinesia and analgesia. The use of ophthalmic regional

blocks depends on the preferences, education, and training of ophthalmologists and anesthesia providers, as well as patient preference and available resources.

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