

A Review article of Topical Anaesthesia in Ocular procedures

Dr. Umeshkumar Suthar¹, Dr. Milind Bhoi²

¹PG Scholar, Department of Shalakyatantra, Tilak Ayurved Mahavidyalaya, pune-411002 Maharashtra

²Associate professor Department of Shalakyatantra, Tilak Ayurved Mahavidyalaya, pune-411002 Maharashtra

Abstract—Topical and intracameral anaesthesia represent modern advancements in pain management for cataract surgery. Topical anaesthesia has proven to be a safe and effective alternative to retrobulbar and peribulbar anaesthesia. These newer methods offer potential safety benefits over traditional injection techniques, which, though rare but can result in serious complications such as globe perforation, retinal vascular occlusion, retrobulbar haemorrhage, strabismus, ptosis, optic nerve damage, or even cardiac and respiratory arrest. Beyond avoiding these risks, topical anaesthesia enables patients to recover their vision immediately after surgery. It is one of the most frequently used techniques in ophthalmic surgeries, particularly for cataracts. Additionally, it reduces the risk of injection-related bleeding in patients on anticoagulants. Topical anaesthesia is ideal for procedures that do not require globe akinesia and is applied directly to the cornea and conjunctiva using local anaesthetic drops or gels such as lidocaine, proparacaine, or tetracaine.

Index Terms—Anaesthesia, Local, Pharmacology, Topical

I. INTRODUCTION

Anaesthesia, derived from Greek words meaning "without sensation," is categorized into general and local types. Local anaesthesia, specifically, numbs a particular area. Local anaesthesia is administered through various techniques: conduction, infiltration, and topical.

While conduction and infiltration anaesthesia offer deep numbness, they involve needles, which can be frightening and painful for patients. Topical anaesthesia, though less potent, is needle-free, has minimal side effects, and can ease the discomfort of injections, making Ophthalmic procedures more tolerable.

This article explores the applications and recent developments in topical anaesthetics in ocular procedures. Topical anaesthesia is defined as superficial loss of sensation in conjunctiva. It delves into traditional and newer products, aiming to provide insights into their use in modern ophthalmic practice.

II. MATERIAL AND METHOD

All literature related to ocular anaesthesia, topical anaesthesia, anaesthetic drugs from various authentic books, various research paper and web search etc.

III. AIM

To study Topical anaesthesia in ocular surgeries.

IV. OBJECTIVES

- To study details about topical anaesthesia
- To study the action of anaesthetic drugs used in topical anaesthesia

V. REVIEW OF TOPICAL ANAESTHESIA

In 1884, Karl Koller, an ophthalmic surgeon, demonstrated that general anaesthesia could be avoided for ophthalmic procedures by using cocaine applied to the conjunctiva, marking the advent of topical anaesthesia in ocular surgery [1]. Since then, advancements in anaesthetic agents, specifically the development of amide and ester local anaesthetics, as well as improvements in delivery systems, have greatly expanded the range of uses for topical anaesthesia in the eye (2). The term "topical" derives from the Latin word *topica*, which itself comes from

the Greek word *topikos*, meaning "pertaining to a place" or "topic," while "anaesthesia" originates from Greek, with "an-" meaning "without" and "aisthēsis" meaning "sensation" (3).

VI. ANATOMY OF EYE RELEVANT TO TOPICAL ANAESTHESIA

Understanding the basic anatomy of the eye is crucial for effective application of topical anaesthetics. Key structures involved include:

1. Cornea
 - Function: The cornea is the transparent, avascular tissue that forms the front layer of the eyeball.
 - Innervation: It is highly innervated by sensory fibers from the ophthalmic division of the trigeminal nerve (CN V1), specifically the long ciliary nerves (4).
2. Conjunctiva
 - Function: The conjunctiva is a thin, vascularized membrane that covers the sclera and lines the inside of the eyelids.
 - Innervation: Sensory innervation is provided by the ophthalmic nerve (CN V1) and, to a lesser extent, the maxillary nerve (CN V2) (5).
3. Sclera
 - Function: The sclera provides structural support and protection to the eye.
 - Innervation: The sclera has less sensory innervation compared to the cornea, with branches from the long and short ciliary nerves (6).
4. Eyelids
 - Function: Eyelids protect the ocular surface and facilitate tear distribution.
 - Innervation:
 - Upper eyelid: Innervated by the ophthalmic nerve (CN V1) via the supraorbital and supratrochlear branches.
 - Lower eyelid: Innervated by the maxillary nerve (CN V2) via the infraorbital nerve (7).
5. Lacrimal System
 - Function: The lacrimal system includes the lacrimal gland, responsible for tear production.

- Innervation: The lacrimal gland receives parasympathetic innervation from the facial nerve (CN VII), along with sensory fibers from the ophthalmic nerve (CN V1) [8].
- 6. Anterior Chamber Structures
 - Function: This includes the iris, ciliary body, and trabecular meshwork, crucial for regulating intraocular pressure and fluid drainage.
 - Innervation: Sensory innervation of the iris and ciliary body comes from long and short ciliary nerves [9].

VII. INDICATION

Topical anaesthesia is widely used in ophthalmic practice due to its rapid onset, ease of administration, and minimal systemic effects. The following are common indications for its use:

1. Diagnostic Procedures
 - Slit-lamp examination: Used to assess the anterior segment of the eye, including the cornea, conjunctiva, and lens.
 - Tonometry: Essential for measuring intraocular pressure (IOP), crucial in glaucoma management [10].
 - Gonioscopy: Employed to examine the angle of the anterior chamber for conditions like glaucoma.
2. Minor Surgical Procedures
 - Foreign body removal: For the removal of foreign objects from the cornea or conjunctiva, a painless procedure when topical anaesthesia is applied.
 - Chalazion excision: A small, painless surgical procedure to remove a cyst from the eyelid.
 - Pterygium surgery: Involves the removal of abnormal tissue from the conjunctiva and is typically performed under local anaesthesia [11].
3. Laser Procedures
 - Photorefractive keratectomy (PRK): A laser-based surgery to correct refractive errors, particularly myopia, by reshaping the cornea.
 - Laser-assisted in situ keratomileusis (LASIK): Another procedure aimed at correcting refractive errors, involving a laser to reshape the cornea.
 - Phototherapeutic keratectomy (PTK): A laser procedure used to treat corneal conditions such as scars or pterygia [12].
4. Adjunctive Anaesthesia for Major Procedures

- Cataract surgery: Although cataract surgery is usually performed under regional anaesthesia, topical anaesthesia is often used to supplement the effect, providing additional patient comfort during the procedure [13].

VIII. CONTRAINDICATION

Ester group topical anaesthetics are contraindicated in patients with known allergy to PABA, sulfonamides and hair dyes. And have nystagmus.

IX. PROCEDURE

The application of topical local anaesthetic eye drops to the cornea and conjunctiva should commence in the patient holding area approximately 20-30 minutes prior to surgery. Although various protocols exist, a common practice involves administering two or three drops at five-minute intervals. Over this time, adequate absorption occurs, ensuring anaesthesia of the ocular surface. Since the cornea is avascular, the local anaesthetic, once absorbed, remains effective for approximately 30 minutes. Should the patient experience discomfort during the procedure, additional drops can be applied. Notably, the use of the Honan balloon to reduce intraocular pressure is unnecessary when topical anaesthesia is employed.

During surgery, the patient should be positioned in a comfortable supine posture, ideally with a pillow beneath the knees to reduce lumbar lordosis, thereby mitigating any lower back discomfort. Surgical drapes should be carefully placed to avoid covering the patient's nose and mouth, ensuring clear airways. Oxygenation during surgery can be achieved with various devices designed to deliver oxygen efficiently. Maintaining patient comfort also extends to temperature regulation, as it is critical to ensure a stable and comfortable thermal environment.

Topical anaesthesia alone effectively achieves detectable levels of local anaesthetic agent in the anterior chamber of the eye, providing adequate analgesia for many standard procedures. However, specific surgical techniques, such as iris manipulation, globe expansion, and intraocular lens insertion, may induce discomfort. To enhance intraoperative analgesia, additional local anaesthetic can be injected into the anterior chamber of the eye. Studies have

shown that this approach provides superior pain management, particularly during more invasive steps of ocular surgery [14, 15].

X. ANAESTHETIC DRUGS

Proparacaine and proxymetacaine (also known as oxybuprocaine) are both topical anesthetics commonly used in ophthalmology to numb the outermost layers of the cornea and conjunctiva, typically during eye examinations, minor surgical procedures, or diagnostic tests.

Proparacaine:

- Concentration: Typically used as a 0.5% solution for ophthalmic use.
- Onset: The anesthetic effect begins within 30 seconds of instilling a single drop.
- Peak Effect: The maximum effect is achieved within approximately 5 minutes.
- Duration: The corneal anesthesia lasts for 15 to 25 minutes, which is usually sufficient for most diagnostic and minor surgical procedures.

Proxymetacaine (Oxybuprocaine):

- Concentration: Topically available in a 0.4% solution for ophthalmic use.
- Onset: Anesthesia begins within 20-30 seconds of instillation.
- Peak Effect: The maximum effect is reached within 5 minutes.
- Duration: The duration of anesthesia is approximately 15 to 20 minutes, providing adequate time for brief ocular procedures.

Tetracaine (e.g., Pontocaine):

- Onset: 30 seconds–1 minute
- Duration: 15–20 minutes
- Metabolism: Hydrolyzed by esterases in the corneal tissues.
- Characteristics: Tetracaine is more potent and has a longer duration of action than proparacaine. However, it can be more irritating, particularly on repeated use, and may lead to longer recovery times

Lidocaine (e.g., Xylocaine):

- Onset: 30–60 seconds
- Duration: 15–30 minutes
- Metabolism: Metabolized in the liver.
- Characteristics: Lidocaine is less commonly used in ophthalmic procedures, though it is effective

for short procedures and nerve blocks. Its higher concentration solutions are utilized for specific nerve blocks,

XI. PHARMACOKINETICS

1. Absorption

- **Corneal Permeability:** The cornea serves as the primary barrier to drug absorption due to its complex structure, including the lipophilic epithelium and hydrophilic stroma. Topical anaesthetics that balance lipophilic and hydrophilic properties, such as proparacaine and tetracaine, demonstrate enhanced penetration across the corneal layers (Zagon et al., 1986).
- **Instillation Site:** Drugs administered topically onto the corneal surface are rapidly absorbed due to the large surface area and the presence of the highly vascularized conjunctiva and limbus. (Ansel et al., 2005).
- **Drug Formulation:** The physicochemical characteristics of the anaesthetic, including concentration, viscosity, and the presence of preservatives, can significantly influence absorption. Lower concentrations and preservative-free formulations tend to be preferred in ophthalmology to reduce potential irritation and long-term toxicity (Münch et al., 2008).

2. Distribution

- **Corneal and Conjunctival Tissues:** Upon absorption, topical anesthetics are distributed into the corneal stroma, conjunctival tissues, and potentially the anterior chamber. However, systemic distribution is minimal (Fischer et al., 2014).
- **Blood-Aqueous Barrier:** The blood-aqueous barrier generally prevents significant systemic circulation of the drug. Ophthalmic anesthetics are typically confined to the ocular tissues, and their penetration into the bloodstream is minimal under standard clinical conditions (Swaminathan et al., 2013).
- **Systemic Distribution:** In cases of repeated applications or excessive doses, small amounts of anesthetics can enter systemic circulation via the conjunctiva or nasolacrimal duct, eventually reaching the bloodstream. (Liu et al., 2022).

3. Metabolism

- **Enzymatic Breakdown:** Ophthalmic anesthetics such as tetracaine and proparacaine are primarily metabolized within the corneal tissues by esterases. The ester bond in these anesthetics undergoes hydrolysis in the corneal epithelium and stroma, contributing to the rapid onset and short duration of action (Harper et al., 1994).
- **Systemic Metabolism:** While systemic absorption of ophthalmic anesthetics is minimal, drugs that are absorbed into the bloodstream are primarily metabolized by hepatic enzymes, such as esterases in the liver. (Liu et al., 2022).

4. Excretion

- **Primarily Renal:** Most ophthalmic anesthetics are excreted through the urine, with only trace amounts present systemically due to the limited absorption from the ocular tissues. The renal route is the primary means of excretion (Shah et al., 2015).
- **Minimal Systemic Excretion:** The systemic excretion of these anesthetics remains minimal under standard use, as the drugs are largely confined to the ocular tissues. However, systemic effects may occur if drugs are administered excessively or over extended periods, particularly in patients with impaired renal function (Jindal et al., 2019).

XII. PHARMACODYNAMICS

Topical anesthetics work by reversibly blocking nerve conduction at the site of administration, typically near free nerve endings located in the dermis, mucosa, or cornea. These drugs produce a temporary loss of sensation in the targeted area, which is useful for various medical and surgical procedures. Their mechanism of action involves the inhibition of voltage-gated sodium channels in nerve cell membranes. By decreasing the permeability of the nerve membrane to sodium ions, the anesthetic prevents the depolarization of the nerve, which is necessary for the generation and propagation of nerve impulses.

This inhibition is thought to occur in part by competing with calcium ions for binding sites on the sodium channel, reducing the influx of sodium and, in turn,

inhibiting the activation of action potentials. Normally, sodium influx is critical for the depolarization phase of the action potential, as it allows for the rapid transmission of electrical signals along the nerve. When sodium channels are blocked, the nerve's ability to depolarize is impaired, thus raising the excitability threshold and preventing the propagation of action potentials. The result is a localized loss of sensation, which typically begins within seconds to minutes of application, depending on the specific anesthetic and its formulation.

Topical anesthetics are commonly used in procedures involving the skin, mucous membranes, and superficial ocular structures, such as minor skin procedures, eye examinations. They provide effective and temporary anesthesia, typically lasting for a limited period, making them ideal for short-term use. However, prolonged or excessive use can lead to complications, such as local tissue damage, delayed wound healing, or systemic toxicity, particularly if absorbed in significant amounts.

XIII. DISCUSSION

Topical anaesthesia has become a cornerstone of modern ocular surgery, offering a safe, effective, and minimally invasive alternative to traditional injection-based methods. As demonstrated by Karl Koller in 1884, topical anaesthesia can provide sufficient pain relief without the need for general anaesthesia, revolutionizing ophthalmic procedures. The key advantages of topical anaesthesia include its rapid onset, minimal side effects, and ability to reduce complications associated with needle-based methods, such as globe perforation or optic nerve damage. Furthermore, it facilitates quicker postoperative recovery, as patients often regain vision immediately after surgery. Common agents like proparacaine, tetracaine, and lidocaine are widely used for procedures ranging from diagnostic tests to minor surgeries, with their pharmacokinetic properties ensuring effective local analgesia. However, despite its many benefits, caution is necessary with prolonged use, as it may lead to corneal toxicity or delayed wound healing. Overall, topical anaesthesia continues to evolve, enhancing patient comfort and safety in ocular care.

XIV. CONCLUSION

Topical anaesthesia has revolutionized ophthalmic practice, allowing for a wide range of diagnostic, therapeutic, and surgical interventions with minimal patient discomfort and systemic side effects. By understanding the anatomy of the eye and the appropriate indications for topical anaesthetics, ophthalmologists can enhance patient outcomes and improve procedural efficiency.

REFERENCES

- [1] Koller, K. (1884). "Anesthesia of the Cornea by Cocaine." *American Journal of Ophthalmology*, 1(1), 29-31.
- [2] Hwang, J. M., et al. (2002). "Topical Anesthesia in Ophthalmology: The Past, Present, and Future." *Ophthalmic Surgery, Lasers & Imaging*, 33(4), 235-240.
- [3] Millán, J., et al. (2006). "The Evolution of Local Anesthetics: A Historical Overview." *Acta Anaesthesiologica Scandinavica*, 50(1), 1-10.
- [4] Farkas, T., et al. (1998). "Sensory Innervation of the Cornea." *Journal of Neuro-Ophthalmology*, 18(1), 31-34.
- [5] Alió, J. L., et al. (2000). "The Anatomy of the Conjunctiva and Its Clinical Implications." *Ophthalmology*, 107(6), 1157-1163.
- [6] Young, R. W. (1985). "The Anatomy of the Sclera and Its Functional Role in Glaucoma." *Survey of Ophthalmology*, 29(3), 159-166.
- [7] Lemp, M. A. (1995). "Ocular Surface Disease: Diagnosis and Management." *Ophthalmology Clinics of North America*, 8(2), 247-256.
- [8] Tamm, E. R., et al. (1995). "The Lacrimal Gland and Its Function: Anatomy, Physiology, and Diseases." *Acta Ophthalmologica Scandinavica*, 73(2), 83-93.
- [9] Zhai, M., et al. (2013). "Innervation of the Iris and Ciliary Body." *Current Opinion in Ophthalmology*, 24(6), 520-528.
- [10] Kooner, S. R., et al. (2007). "Clinical Applications of Tonometry in Glaucoma." *Journal of Glaucoma*, 16(6), 634-639.
- [11] Mavrikakis, I., et al. (2001). "Topical Anesthesia in Minor Ocular Surgery." *Ophthalmic Surgery, Lasers & Imaging*, 32(5), 377-381.

- [12] Xu, J., et al. (2009). "Laser Treatments for Refractive Errors and Corneal Disorders." *Survey of Ophthalmology*, 54(3), 323-331.
- [13] Hasso, J. D., et al. (2009). "Topical Anesthesia in Cataract Surgery: A Review of Efficacy and Safety." *Ophthalmology*, 116(6), 1224-1230.
- [14] Smith, J.D., et al. (2021). Topical and intraocular anaesthesia in cataract surgery: Efficacy and complications. *Journal of Ophthalmic Surgery*, 58(4), 340-348.
- [15] Wang, L., et al. (2020). Improved pain control in cataract surgery with intraoperative injection of local anaesthetic into the anterior chamber. *British Journal of Anaesthesia*, 124(2), 225-232.