

Wound Geometry as it Relates to Tunnel Valvular Competence in Manual Small Incision Cataract Surgery

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ABSTRACT

Aim: To describe wound construction in manual small incision cataract surgery (MSICS) in relation to anatomy, physiologic functioning and challenges of sclerocorneal tunnel. **Methods:** The author's method of wound construction during MSICS was explored in a lucid prose. Where relevant, information obtained from major scholarly databases (Scopus, Hinari, PubMed and Google Scholars) was cited. **Results:** Valvularly competent sclerocorneal tunnel largely contributes to the outcome of sutureless MSICS and takes practice to master. **Conclusion:** Core to a successful MSICS is the construction of a leak-proof sclerocorneal tunnel.

Keywords: Incision anatomy, incisional funnel, sclerocorneal pockets, sclerocorneal tunnel

INTRODUCTION

Today many surgeons are keen to convert from sutured to sutureless cataract surgery. As with all surgeries, manual small incision cataract surgery (MSICS) also needs experience to be mastered, especially construction of a leak-proof valvular tunnel. Once extracapsular cataract surgery (ECCE) is mastered, scleral tunnel construction becomes the major outstanding hurdle in conversion to MSICS. Additionally, maintaining the integrity of the scleral tunnel in the course of ocular instrumentation and intraocular maneuvers through it requires dexterity that only accompanies constant practice.

The aim of this article is to present a descriptive analysis of a familiar technique involved in wound construction in MSICS to trainee MSICS surgeons.

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WOUND ARCHITECTURE: ANATOMIC AND PHYSIOLOGIC CONSIDERATIONS

Key to constructing a competent MSICS tunnel is maintenance of overall self-sealing wound architecture which may be linked with some anatomic or physiologic parameters mentioned below.

First, tunnel valvular effects appear hinged on apposition of two opposite corrugated sclerocorneal surfaces, whereby, the upper surface interdigitate in perfect unison with the lower surface.

Second, for a wound to be self-sealing, Ernest *et al.*^[1] had proposed "square incisional geometry." This concept states that an ideal self-sealing wound has a length equal to its width. In reality, however, the length is usually smaller because of the need to have expanded wound to allow the exiting nucleus. As a compromise, therefore, the author constructs a stereo-image that opens up as a leaflet of inverted trapezium that ensures a spacious tunnel for nucleus delivery and, yet valvularly competent.

Third, an irregular layer of "scleral fluid" within the matrix of the two interdigitating surfaces is being

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proposed by this article to explain a leak-proof physiologic barrier to intraocular saline or air used to maintain anterior chamber (A/C) after completion of surgery. Additionally, fluid dynamics in the A/C tend to push the internal and external lips of the cornea wound together sealing it like an envelope or valve.

Fourth, Ruchi and Malik^[2] had mentioned that A/C must be entered close to 3 mm anterior to Schwalbe's line (2 mm from anterior border of conjunctival attachment onto cornea, through a beveled wound) for the corneal part of the sclerocorneal tunnel to have an autovalve effect.

Lastly, an important concept in understanding incision design in MSICS is that of the incisional funnel [Figure 1] described in 1991 by Paul Koch.^[3] The funnel represents an imaginary safe area, where incision of any length can be placed with minimal effect on corneal curvature. The effect of size and location of scleral incision on corneal curvature has been extensively studied by Samuelson *et al.*, Gills and Sanders.^[4,5] Corneal astigmatism is directly proportional to the length of scleral incision and inversely proportional to the distance of the incision from the limbus.^[5] Incisions made within incisional funnel are astigmatically stable. Short linear incisions made close to the limbus and longer incisions farther away are equally stable. The optimal length of scleral incision has been determined to be 6-8 mm and a distance from limbus 2-3 mm.^[6,7]

There are two incisions in the scleral tunnel wound for MSICS—the external scleral incision and the internal corneal incision [Figure 2]. The external wound dimensions have an important bearing on the self-sealing nature of the wound, with smaller incisions being more reliably self-sealing than larger ones. A small external wound, however, presents an obstacle to the delivery of the nucleus and IOL implantation as mentioned above.

There are several external scleral incisions including smiling or anti-frown, frown, inverted V-shaped, scleral flaps and straight. The smiling incision is least popular being associated with significant flattening and the only one that falls outside the incisional funnel.^[2] The frown incision described by Singer^[8] reduces the amount of induced astigmatism, provide more stable cornea, and more spacious for intraocular lenses. The inverted V-shaped scleral incision described by Gills^[5] gives an overall effect of a frown incision. Hirshman^[9] and Maloney and Shapiro^[10] had described various scleral flap incisions, wherein a trabeculectomy flap connects a corneal valve. Dissection being under direct visualization, it well suits a beginner but has a demerit of requiring sutures same as a trabeculectomy

scleral flap. The straight incision, the preferred method by the author, is simple and fits within the incisional funnel. The only drawback is that placing the incision too fall away makes the maneuvering of instruments difficult in long scleral tunnels.

SURGICAL TECHNIQUE

The fact that scleral tunnels can be carried out in variety of ways is acknowledged. The procedure described in this article makes use of the cut-edge of a razor blade on blade breaker handle, crescent knife, and keratome. The author is aware and conversant with using a cut-edge of a razor blade for tunneling same as the crescent knife and then A/C entry same as keratome. However, the technique described here is a step-ladder, one-instrument-per-stage approach that well suits learners for which this article is intended.

Surgical procedures involves a fornix-based conjunctival peritomy with Westcott's scissors. Bleeders are lightly cauterized. A scleral "nick" or scratch is made away from the proposed site of the tunnel. This nick is engaged with a colibri or toothed forceps to hold the globe for a controlled dissection. Linear scleral incision about 2 mm posterior to surgical limbus and about 5.5-6.5 mm long (measured with Castroviejo's calipers) is made with a cut-edge of a razor blade (non-stainless type). Other authors have used guarded diamond knife or keratome or a surgical blade no. 11/15 on a Bard-Parker handle.^[2,11] Incision sizes should be based on the anticipated size of the nucleus. Fairly large wound sizes are necessary for hard mature cataracts. Lens Opacities Classification System (LOCS) grade II cataracts can be molded through a relatively small scleral tunnel.

All incisions should however be at least 6 mm for smooth PMMA intraocular lens (IOL) entry during the implantation. From the external scleral incision, sclerocorneal tunnel dissection is effected from then on. With a bevel-up angled 2.8 mm tunnel blade/crescent knife at a depth of 0.3 mm, a scleral tunnel is dissected forward till the limbus; the blade is lifted up along the dome of the cornea to dissect the clear corneal tunnel up to about 2 mm into clear cornea and extended laterally to produce sclerocorneal pockets on both sides [Figure 3]. At the anterior-most part of the inner tunnel already 1-2 mm into clear cornea [Figure 4], angled 45 degree 3.0 mm bevel-up microkeratome is tilted downwards to create a dimple to enter the A/C. With anterior and lateral movements, wound is uniformly (parallel to limbus) extended into the side pockets earlier created by tunneling, flaring into an inverted trapezoid opening [Figure 5]. Generally an 8-9 mm corneal lip suffices for the internal incision.

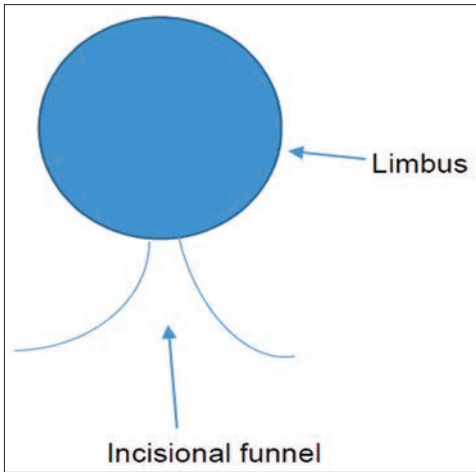


Figure 1: Incisional funnel

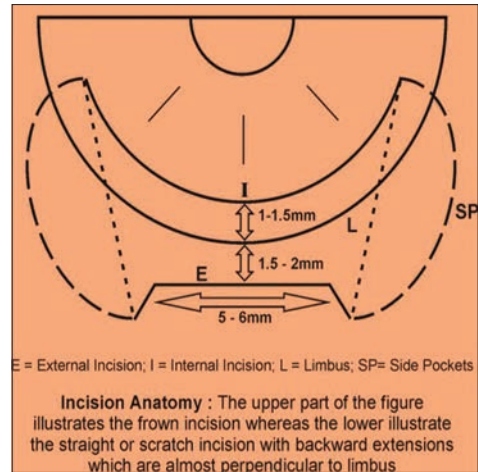


Figure 2: Incision anatomy

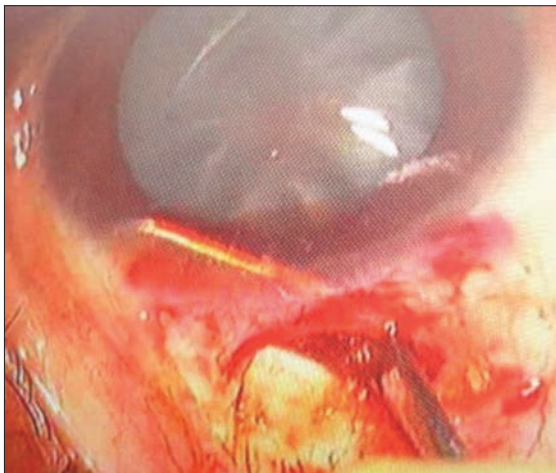


Figure 3: Creating a left side sclerocorneal pocket with crescent knife

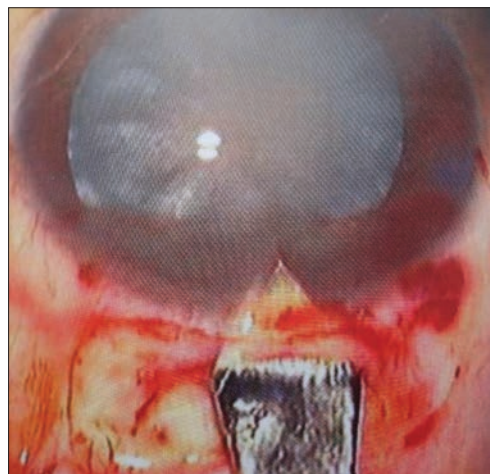


Figure 4: A/C entry with keratome at the anterior-most end of the tunnel

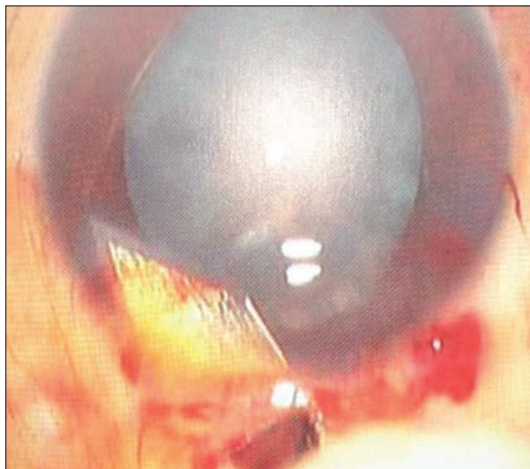


Figure 5: Extension of keratome incision into left side sclerocorneal pocket

TUNNEL FAILURE

Scleral tunnel can be said to have failed if it is valvularly incompetent resulting in non-forming

A/C/soft globe and requiring at least a suture despite adequate corneal stromal hydration. Adequate stromal hydration means hydration of the side-port and lateral margins of the tunnel. The most common causes of a failed tunnel is scleral button-holing and premature entry. Others are amputated scleral flap, non-uniform A/C entry at the level of clear cornea and multi-planar tunneling [Table 1].

MANAGEMENT OF TUNNEL FAILURE

Scleral button-holing

This can occur inadvertently but the episodes should decline with proficiency in tunnel construction. A harbinger to scleral button-holing is excessive visibility of the tunneling blade. High level of concentration is often needed to notice whenever this occurs, and at such instances, the tunneling blade is made to burrow deeper into the underlying scleral tissues for a fresh and deeper scleral plane. It is noteworthy that at every stage of tunneling, the tunneling blade should remain "just visible" (0.25-0.3 mm deep) and no more.

Table 1: Causes of tunnel failure

| |
|---|
| Scleral button-holing |
| Charred scleral from excessive cauterization |
| Too superficial tunneling |
| Poor view during tunneling |
| Abnormal angulation of the tunneling blade |
| Blunt tunnel blade |
| Redundant residual tenons |
| Extension of tunnel to initial scleral "nick" |
| Conditions causing scleral thinning: e.g., high myopia |
| Premature entry |
| Too deep tunneling |
| Non-recognition of corneal dome |
| Avulsion of any part of the roof of the tunnel |
| Holding onto the roof of the flap during tunneling |
| Ragged extension of scleral lip beyond the initial clean scleral blade incision |
| Multi-planar tunnel |
| Non-uniform A/C entry at the level of clear cornea |

Whenever a scleral button-hole eventually occurs, the wound construction need not be abandoned as there are options to achieving competent valvular effects.

For a learner, it is safer to abandon the area the button-hole occurs for a virgin area within the raised partial thickness scleral flap and go slightly deeper for a new scleral plane. This new plane is then gently extended to go underneath the breached portion of the overlying sclera. Again, the tunneling blade must not go too deep as not to make it invisible per time. Alternatively, in the experienced hands, following an inadvertent scleral button-holing, the crescent knife is placed on the floor of the tunnel just anterior to the breached roof, it is then angulated in such a way it takes up a fresh bite of the sclera. The same is then raised in the conventional way until it is made to go underneath the breached sclera.

Premature entry

The cornea forms a dome, non-recognition of which results in premature entry of the A/C resulting in immediate shallowing of A/C, soft globe, difficult tunneling and iris prolapse. Deliberate and controlled advancement of the crescent knife through the contour of the globe especially at the limbus is critical to avoiding either a button hole or premature entry. Some knives could be just slightly thicker than usual, it could lead to an inadvertent button hole creation. Whenever, there is premature entry, especially with a trainee, the tunnel should be abandoned for that moment for one of the following options:

Intracameral viscoelastic is injected into the A/C to achieve a firm taut globe for a more careful completion of tunneling in other areas where A/C is not yet entered. A suture may be necessary after the surgery

depending on how the subsequent stages of the wound construction are managed.

Alternatively, capsulotomy/rhexis is carried out passing the cystiotome through the point of inadvertent A/C entry. For easier visibility of anterior capsule for Continuous Curvilinear Capsulorrhexis (CCC), intracameral trypan blue (preferably preceded with air in the A/C) is used to stain it. A/C should be reformed sufficiently with viscoelastic solution during CCC for uneventful intraocular instrumentation and manipulations. Thereafter, the tunneling is completed and side-port created in the conventional way.

SEQUELAE OF TUNNEL FAILURE

Non-forming A/C after surgery

A/C may not form despite sufficient hydration of the side-port and the lateral margins of the tunnel. Non-forming A/Cs are persistently shallow, the globes are soft and not enough air or saline is retained in an attempt at A/C formation. If A/C does not form as a result of incompetent valvular system of a tunnel, variable numbers of interrupted 10/0 nylon sutures should be applied.

Malfunctioning side-port

It should be borne in mind that poorly fashioned side-port may also contribute to non-forming A/C despite a well-constructed competent tunnel. In such circumstances, the side-port may be sutured if local stromal hydration fails to achieve the desired effect.

MANAGEMENT OF DESCMET STRIPPING

Stripped Descemet's membranes may occur during A/C entry with a blunt keratome or due to wrong techniques. Such techniques will include inadvertent hydrodissection of Descemet's membrane during intraocular injection of saline, viscoelastic and Trypan blue. To avoid this, it is crucial to see the tip of the cannula in the A/C before injections are made. Management of a stripped Descemet's membrane starts with early recognition to minimize its severity. At the completion of the surgery, the stripped often retracted Descemet's membrane is gently uncoiled with iris repositor and tamponade in place with intracameral air.

WOUND-RELATED MERITS OF SUTURELESS TUNNELED CATARACT SURGERY OVER SUTURED CONVENTIONAL ECCE

Sutureless tunneled cataract surgery obviates sutured-induced astigmatism and irritation. The prevalence of ATR astigmatism significantly increases

with age, and WTR astigmatism significantly decreases with age. It is thought that reduced eyelid tension with age causes flattening of the vertical corneal meridian, thereby decreasing WTR astigmatism and increasing ATR astigmatism.^[12] Temporal incision can be explored to minimize ATR and achieve superior vision in older patients who undergo MSICS.

Other known wound-related merits are reduced incidence of iris prolapse and postoperative hyphema. Suturing being often needless, the economic viability and speed of surgery are twin factors that have made MSICS gain widespread adoption. It is particularly found useful in eye camps and high volume cataract surgery centers.^[13,14]

NUGGETS

Good patient selection is a key for the beginner MSICS surgeons. The ideal case should be immature cortical or LOC grade II-III nuclear sclerosis that can be molded through the scleral tunnel. The trainee should be encouraged to perform a more familiar can-opener capsulotomy, while concentrating on the tunnel construction and geometry at initial stages. Meticulous clearing of redundant sub-tenons will allow for easy tunneling. Not more than light cauterization of bleeders is necessary to ensure that the scleral tissue is not charred. Corneal lip of the tunnel could be advanced extra 0.5 mm in cases where scleral end is less than 2 mm from the limbus, often arising from poor initial estimation of scleral incision or ragged margin of scleral lip. The entire wound should be revisited by horizontal to and fro movements with crescent knife/keratome to make sure it has been thoroughly dissected. When necessary, crescent knife/keratome can be used for wound expansion or completion of partial dissection.

Meticulous considerations should be given to tunnel geometry at the commencement of surgery. Preferably the incision anatomy is marked/sketched on the surgical field with the blunt end of surgical blade or any blunt pointed instrument.

Crescent knife and keratome should be sharp to avoid ragged incisions, pulling or compressing the globe during tunneling. Blunt knives can result in Descemet's stripping at site of A/C entry. For retained fragmented nucleus following Vectis-Sinsky phaco-sandwich delivery, the tunnel need not be extended. In such a circumstance, the nucleus should be rotated so that its long axis is perpendicular to the horizontal incision and the same sandwich technique attempted. Alternatively, a continuous jet of viscoelastic agent is directed to the

posterior pole of the rotated fragmented nucleus; by gentle depression of scleral lip of the tunnel with the cannula with which viscoelastic is being injected and the posteriorly built up conventional current guides the fragmented nucleus out (visco-expression).

It is advocated that some degree of competence in conventional ECCE can be achieved to ease conversion to sutureless tunneled MSICS. Studies^[15-17] have reported reduced duration of learning, reduced adverse intraoperative complications and improved overall quality of surgical outcome when a trainee has a modest mastery of ab-externo extracapsular cataract surgery.

The target of MSICS is not to suture the surgical wounds; however, suturing is advised in these situations: Fat patients with short necks, unstable wound, children, combined procedures, patients with chronic cough, disturbing iris prolapse, implantation of AC-IOL, large wounds, multiplanar incisions, vitreous retention in A/C following posterior capsular rent, a failed tunnel, etc.

CONCLUSION

MSICS is the cataract surgery of choice in most developing countries being economical and universally applicable to all grades of cataract. Consequently, many postgraduate medical training centers in Nigeria have begun mentoring ophthalmic residents in MSICS. It is believed that this article will provide a valuable resource in the learning milestones of trainee MSICS surgeons.

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