Recent Advances of Drainage Devices in Glaucoma Surgery

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Abbreviations

AC	Anterior chamber
AGV	Ahmed Glaucoma Valve
BSS	Balanced saline solution
GDD	Glaucoma Drainage Device
GFS	Glaucoma filtration surgery
GMS	Gold Micro Shunt
ICES	Iridocorneal endothelial syndrome
IOP	Intraocular pressure
MMC	Mitomycin-C
OAG	Open angle glaucoma
OHT	Ocular hypertension
PKP	Penetrating Keratoplasty
PMMA	Polymethylmethacrylate
POAG	Primary open angle glaucoma

Introduction

Glaucoma is a group of optic neuropathies with a slowly progressive degeneration of the retinal ganglion cells and their axons, resulting in a distinct appearance of the optic disc and a concurrent pattern of vision loss ***(Weinreb and Khaw, 2004)***.

Vision loss associated with this disease is irreversible. The biological basis of glaucoma and the factors contributing to its progression have not been completely determined and the intraocular pressure (IOP) is the only proven treatable risk factor in glaucoma ***(Acheson, 2010).***

Glaucoma is theoretically defined as a progressive optic neuropathy as a result of elevation of IOP above the physiological level of individuals. The upper limit of "normal" IOP, based on a large number of subjects, is internationally accepted as being approximately 21 mmHg as a standard in the clinical diagnosis of glaucoma. There are numerous medical and surgical strategies used in the management of glaucoma ***(Foster et al, 2002).***

The main goal of surgical glaucoma treatment is to reduce the intraocular pressure. The standard procedure over the past 40 years has been trabeculectomy, first described in 1968. This procedure comes with a very high risk profile, and results in moderate long-term results at best. Tube shunt devices were introduced as an alternative means to divert fluid out of the glaucomatous eye, attempting to improve upon the poor long-term outcomes of trabeculectomy, particularly in refractory cases that had failed attempts at prior glaucoma surgeries. The number of available glaucoma drainage implants has increased in recent years and now offers additional therapeutic opportunities in refractory glaucoma patients ***(Reinthal et al, 2010).***

Aim of the Work

The main aim of this work is to review articles on glaucoma drainage devices (GDDs). In particular, recent types of glaucoma drainage devices, indications, techniques, and postoperative complications.

Anatomy

Anatomy of Retinal Ganglion Cells and Optic Nerve

Axons from the retinal ganglion cells consist of the innermost layer of the retina, the nerve fiber layer. These axons converge on the optic disc and form the optic nerve, which contains a central depression called the cup (Fig. 1A). Most optic nerves have a visible physiological cup, which is surrounded by a neuroretinal rim (Fig. 1B). The human optic nerve contains approximately 1.2 million nerve fibers, which exit the eye after passing through the lamina cribrosa, a series of perforated connective tissue sheets, and synapse in the lateral geniculate nucleus of the brain ***(Weinreb and Khaw, 2004)***.

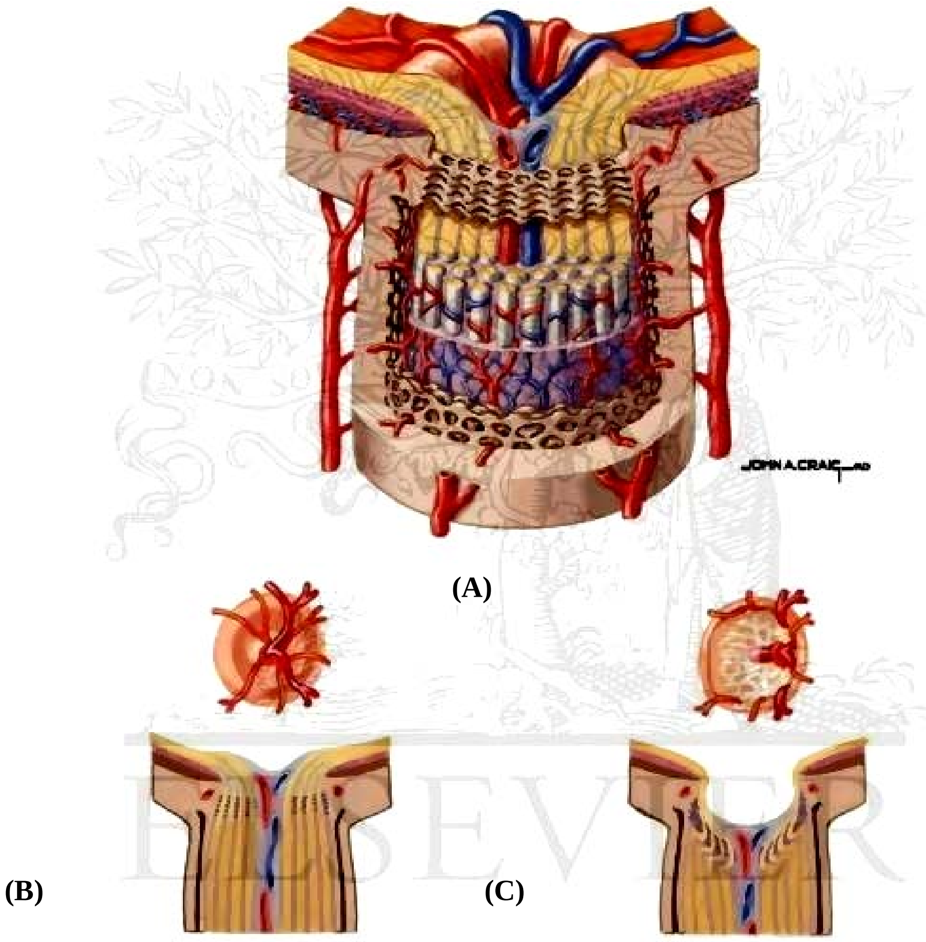

Fig. (1): Anatomy of the optic nerve (A), Normal optic disc (B), Glaucomatous cupped optic disc (C) (Weinreb and Khaw, 2004).

Anatomy of the lamina cribrosa:

The sclera is perforated posteriorly about 3 mm medial and 1 mm above the posterior pole of the eyeball by the optic nerve. Here the sclera is fused with the dural and arachnoid sheaths of the optic nerve. Where the optic nerve fibers pierce the sclera it is weakened and has a sieve-like appearance and is known as the lamina cribrosa (Fig. 2). One of the openings in the lamina is larger than the rest and transmits the central retinal artery and vein. Since the lamina cribrosa is a relatively is a weak area, it bulges outward by a rise in intraocular pressure, producing a cupped disc (Fig. 1C) ***(Jonas et al, 2004).***

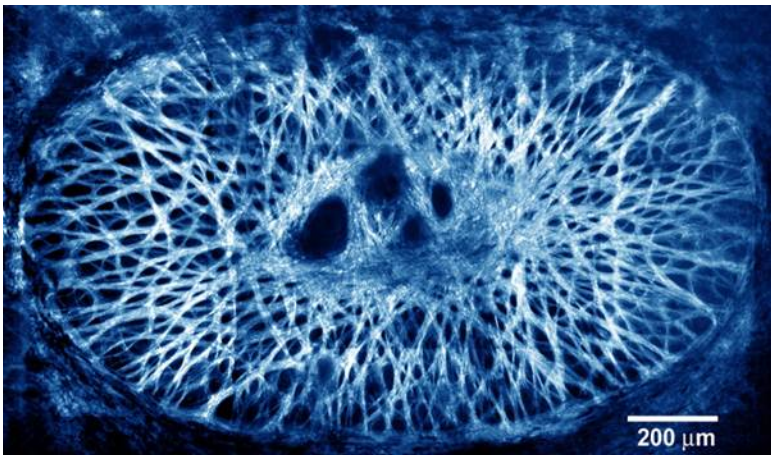

Fig. (2): Anatomy of the lamina cribrosa by second harmonic generation imaging (wavelength dependent microscopy) (Jonas et al, 2004)

Anatomy of the limbus and the anterior chamber:

It measures about 1.5 to 2 mm wide and there is a shallow groove on its outer sulcus, known as external scleral sulcus. On the inner surface a similar groove called internal scleral sulcus, contains the trabecular meshwork and the canal of Schlemm. The posterior lip of the internal scleral sulcus forms a projecting ridge of scleral tissue known as scleral spur which is triangular with its apex pointing anteriorly and inward. Attached to anterior surface of the spur is the trabecular meshwork. The posterior surface of spur gives attachment to ciliary muscle, (Fig. 3) ***(Tsubota et al, 2002)***.

The corneal epithelium becomes the epithelium of the bulbar conjunctiva. Bowman's layer becomes continuous with the lamina propria of the conjunctive and Tenon's capsule. The stroma of the cornea gradually loses its uniform and orderly arrangement and becomes the sclera. Descemet's membrane ends abruptly at Schwalbe's line and just posterior to this the trabecular meshwork begins (Fig. 3). The corneal endothelium is continuous laterally to line the passage of the trabecular meshwork and then continues to the anterior surface of the iris ***(Snell and Lemp, 1998)***.

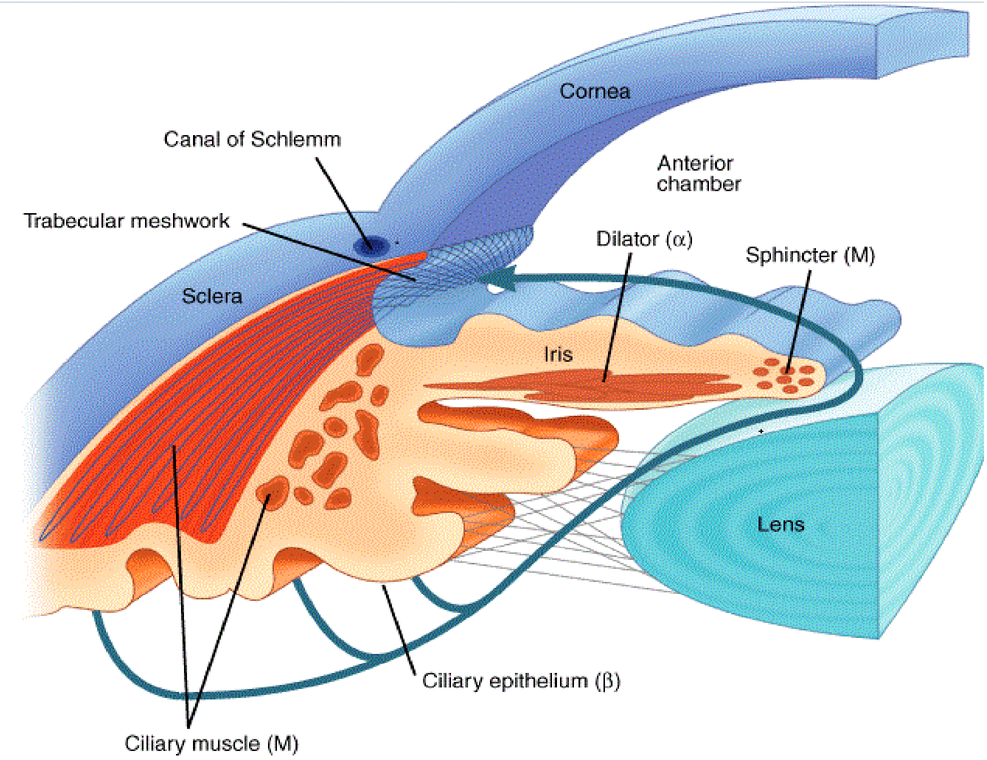

Fig. (3): The structures of the anterior chamber angle (Ross et al, 2004)

The canal of Schlemm (sinus venosus sclerae):

The canal of Schlemm is a canal lined with endothelium that runs circularly around the eyeball at the limbus (Fig. 4). The sinus, which is oval or triangular in cross section, lies within the internal sulcus. It is therefore related posteriorly to the scleral spur. The inner wall of the sinus is related to trabecular meshwork and the anterior chamber. There is no direct communication between the venous sinus and the passages of the trabecular meshwork or the cavity of the anterior chamber. In fact the lumen of the venous sinus is separated from the lumen of the passage by the sinus endothelium, connective tissue wall of the sinus, and the endothelial lining of the passages. Electron microscopic examination of the endothelial cells lining the wall of the sinus venosus sclerae shows giant vacuoles in the cytoplasm. This explains how the aqueous humor leaves the lumen of the trabecular passages to enter the lumen of the sinus venosus (Fig. 4) ***(Ross et al, 2004).***

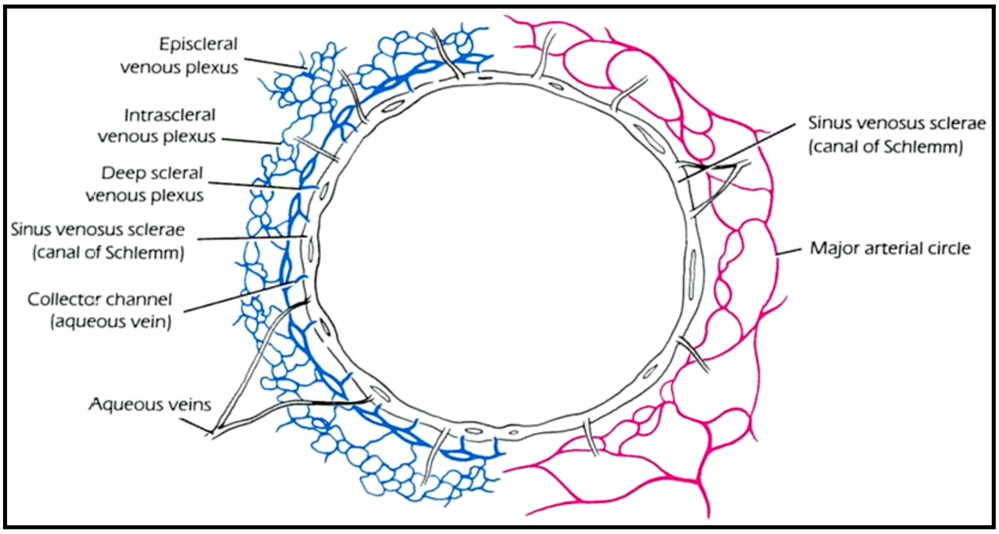

Fig. (4): Canal of Schlemm and its associated veins and arteries (Ross et al, 2004)

Anatomy of the Tenon's capsule:

The Tenon's capsule is thin membrane that envelops the eyeball and separates it from the orbital fat. It forms a socket for the eyeball. The inner surface of the sheath is smooth and shiny and is separated from the outer surface of the sclera by a potential space called the episcleral space. Anteriorly, the Tenon's capsule is firmly attached to sclera about 1.5mm posterior to the corneoscleral junction. Posteriorly, the sheath fuses with the meninges around the optic nerve and with the sclera around the exit of the optic nerve. The main function of the Tenon's capsule is to position and support the eyeball within the orbital cavity and permit the actions of the extrinsic muscles to produce movement of the eyeball (Fig. 5) ***(Snell and Lemp, 1998)***.

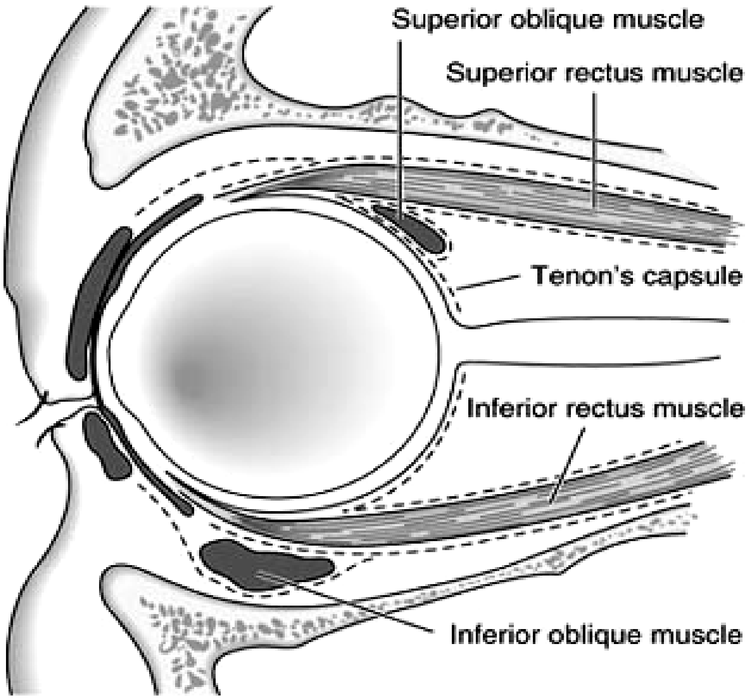

Fig. (5): Anatomy of Tenon's capsule (Snell and Lemp, 1998)