Ever wonder why the cornea is so feared? Why everyone worries about touching it? Well let’s explore the layers of the cornea and see if we can shed any light on this.

The cornea is a remarkably tough tissue – if you ever get the chance to watch cataract surgery, you will see how much the surgeon pulls on the cornea. And I can assure you that on the one-day follow-up visit, you would never know! YouTube has a number of surgery videos you can watch – though there is nothing like the real thing.

The cornea is made up of five basic layers. From the outside, they are the epithelium, Bowman’s layer, stroma, Descemet’s membrane and the endothelium. The typical healthy cornea averages only about 0.5mm thick at the centre. In our offices, this corneal measurement is done using a pachymeter. Why do we care about this measurement? Well, aside from the obvious — laser refractive surgery correction — it is also critical in determining a patient’s true intraocular pressure in the diagnosis and management of glaucoma. A simple search of “corneal layers” under images on the Internet will bring up some great illustrations, including histological slides – those slides that illustrate what tissues look like under a microscope.

We often associate eye pain with the cornea. This is because the cornea is rich in nerves, nerves that penetrate up to within two cell layers of the surface. These nerves enter the corneal epithelium from the limbus (the junction between the cornea and sclera), where they leave behind their myelin sheath. Myelin is the coating around a nerve that allows impulses to travel quickly along the channel. The entire epithelium measures only about 50µm thick – that’s about 1/10th of the overall corneal thickness, or 0.05mm. Bowman’s layer is composed of fine collagen fibrils in random arrangement. This random distribution makes the layer very tough to penetrate, even with the Alger Brush used to remove foreign body rust marks from the cornea.

What happens when a patient gets a corneal abrasion? Well we need to ensure that the eye doesn’t become infected, so treatment with a broad spectrum antibiotic is encouraged, as is cleaning of the edges, artificial tears for lubrication, and the use of a bandage contact lens. Because of the exposed
corneal nerves, abrasions tend to be painful. Pressure patching of an eye to ensure that the lid doesn’t continue to irritate the cornea is no longer advised due to the risk of fungal infections. That’s when bandage contact lenses come into play. Medication and lubricating drops can continue to be instilled, while protecting the exposed and healing tissue from lid and air irritation.

Have you ever seen patients who come into the office sometime after their original injury complaining of recurrent pain? This condition, known as recurrent corneal erosion, or recurrent corneal abrasion, occurs when Bowman’s membrane is damaged and corneal healing has been delayed. The resulting poor attachment of the new epithelium to the stroma results in the epithelium getting sloughed off at random intervals, usually following periods of dryness. The most common time for the recurrence to occur is upon waking – when overnight dryness has caused the lid to stick to the poorly healed surface epithelium. So, you wake up, and bam – you just ripped off the top protective layer and exposed those corneal nerves again! Ouch! The key to proper healing is to ensure that all the epithelium that is not attached to deeper layers is cleaned off completely, providing the cornea with a clean leading edge from which to regrow. If the new epithelium is still not healing well, there are chairside treatments (such as anterior stromal micropuncture) or laser treatments (such as PTK=Phototherapeutic Keratectomy), that can be done to irritate Bowman’s and lead to improved cell adhesion. In all cases, however, it is recommended that the eye be well lubricated, especially at night, to avoid sticking of the lid to the cornea.

So delving deeper into the eye, we meet the stroma. The stroma makes up the bulk of the cornea and is composed of 60-70 successive layers. These are well organized layers laid down in such a way as to maintain the clarity of the cornea while providing maximum mechanical strength. There are also cells, called keratocytes, within the stroma that remain dormant until they are called into action from injury or inflammation. These keratocytes work to ensure that as the cornea heals, the collagen cellular arrangement and stromal clarity will be maintained. When numerous stromal layers are removed, as in refractive laser surgery, most do not regrow. This accounts for the permanent corneal curvature change associated with the surgery.

Deeper into the cornea lies Descemet’s membrane. Descemet’s membrane acts as a basement membrane (think adhering layer) for the endothelium. In keratoconus, where the cornea bulges forward, there is a thinning of Descemet’s membrane that ultimately can lead to a rupture of the layer. This adds a complicating factor to the coned eye in that the integrity of the tissue is now compromised and fluid from the anterior chamber can now easily flow into the stroma and fill the space around the collagen fibrils with fluid. Any extra fluid within a tissue is known as edema, or swelling. The endothelium then forms the boundary between the anterior chamber and the cornea. It is heavy with mitochondria, which forms chemical energy for the cells. Why do we need all this energy in the cornea? Well, as the barrier between the cornea and the anterior chamber, the endothelium is tasked with regulating fluid within the cornea. Following the rules of osmosis, in which water will move from an area of high concentration to an area of lower concentration, so will the aqueous fluid desire to move from the anterior chamber into the cornea.
Fuch’s Dystrophy is a condition in which endothelial cells die off, leaving gaps in this corneal barrier. With the lack of endothelial cells, so comes a lack of mitochondria. The result? An edematous cornea. Salt solutions have been used in the past to help control the edema. These work by creating a salty tear that has a lower concentration of water compared to the cornea. Again, following the rules of osmosis, the extra water that has entered the cornea from the anterior chamber will be drawn forward and out of the eye effectively decreasing the concentration of the salt in the tears. Ultimately, however, patients suffering from Fuch’s Dystrophy will continue to experience increased endothelial cell loss and often will require an endothelial corneal transplant.

Corneal transplants are perhaps the most interesting body tissue to transplant. As the cornea is avascular (without blood vessels) it does not require blood type matching to transplant. Further, the cell layers of the cornea can be separated, permitting up to five people to be helped by a single donor cornea! Because of this easy match, only about one in four transplant recipients will experience graft rejection, which when detected early enough, can be reversed in nine out of 10 patients with medication, leaving the new cornea undamaged. Permanent clouding of the corneal transplant occurs in less than 5 percent of cases.

So that brings up the question, “Why don’t we have any blood vessels in the cornea?” The obvious reason is that blood vessels would interfere with vision – so they aren’t there! Because we know that blood vessels support blood circulation, which in turn, provides oxygen and nutrients to tissues, how does the cornea get its required oxygen and nutrients? The vast majority of the required oxygen of the eye is received from direct contact of air on the surface of the cornea. Some oxygen and nutrients are received from the aqueous humor in the anterior chamber, and the balance comes from the limbal blood vessels. When looking at the limbus under magnification, we can see that the blood vessels come up to the cornea and turn back – or at least they should. Unfortunately, for many of us, fine, frail blood vessels enter the cornea. The growth of these unwanted vessels is termed neovascularization in that neo=new, vascular= vessels, and ization=the process of doing something. They are unwanted in that their continued growth could impede vision by growing to the point where they are visible to the viewer, as well as being weaker in composition, and therefore, more prone to leakage. We want a clear cornea – not one full of blood!

Neovascularization occurs as the body’s response to a lack of oxygen. The oxygen-starved tissues send out a signal asking for more oxygen, and the body responds by sending in more blood. Therefore, this is a common complication of contact lens wear, especially lenses that do not permit oxygen exchange through the material, such as traditional soft contact lenses. When the eye is again exposed to an oxygen-rich environment, the blood vessels may empty of blood, leaving behind ghost vessels (the vessel walls), which are ready to refill at any time the body asks for more oxygen again!

The cornea – scary or remarkable? I’ll leave that for you to decide.
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