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ARE DIAMONDS THE CLEAR CHOICE FOR CLEAR CORNEAL CATARACT SURGERY?

Some considerations of the materials currently used to produce ophthalmic blades, their effect on the incisions made, and the surgical outcomes.

Why Clear Cornea?

When I converted my cataract surgery entirely to clear cornea under topical anesthesia in early 1992, I did so because I quickly embraced its advantages. These advantages were the elimination of a number of steps in scleral surgery such as traction sutures, conjunctival incisions, scleral cautery, and conjunctival closure. I performed all surgery from a temporal incision, and since I was already performing 3 mm sutureless incision with foldable IOLs, the transition was easier for me.

Early on, clear corneal surgery excited the ophthalmic community and gained widespread popularity. There were also early reports of wound leaks, endophthalmitis, and other surgical complications. This has been contrary to my own experience of fewer complications and not one case of endophthalmitis in 15 years of clear corneal surgery! In recent years, new reports of leaking wounds, hypotonous eyes[1], and increased rates of endophthalmitis[2] have surfaced causing a re-examination of clear corneal techniques.

Moving Cataract Incisions to Clear Cornea.

To successfully move incisions to clear cornea requires the surgeon to closely examine technique of would placement, wound architecture, wound sealing, and subsequent wound healing. Manufacturers have been forced to convert to mostly injectable IOLs as well as smaller, more efficient, and safer phaco instruments.

From the beginning, the central spotlight was and always has been on the creation of the corneal tunnel. Temporal corneal tunnels, 3 mm or less, that are square or nearly square are the most stable and refractively neutral. (Fig 1) The increased strength of the square tunnel was shown early on by Ernest et al[3] and more recently Masket[4].

Why Diamonds?

When I first began clear corneal incision cataract surgery in 1992, I had extensive experience as an RK surgeon with corneal wounds and their subsequent healing. History is often our best teacher and it made sense to me to look at my RK experience when moving my incisions from the sclera into clear cornea. The lessons learned from the RK days could easily be applied. Accuracy, reproducibility, and wound healing were paramount in producing successful results. All three of these areas showed significant improvement when moving from razor blades (stainless steel) to **diamond blades**. For these reasons, I went directly to diamonds when I started doing clear corneal cataract surgery. I collaborated with Ron Dykes (Diamatrix, The Woodlands, Texas) to create the first trapezoidal blade for incisions to reduce wound stretching. I believe that the diamond and the new designs have been a significant factor for the excellent results I have experienced. Certainly, though, we should critically consider comparing blade materials, manufacturing techniques, and their effect on wound creation.

Blade Materials and Manufacturing Techniques

Over the past several decades a variety of materials and techniques have been implemented in the manufacturing of micro surgical blades (Diamond, Sapphire, Black Diamond, Ceramic Composites, Stainless Steel). Here are some observations that I have made.

Sharpness (Edge)

When diamonds or other crystals (sapphire, ruby, etc.) are used to produce these blades two techniques are employed. The first is honing or lapping technology that was developed and primarily used in the United States and Europe. When using this technique the harder the material the sharper the blade. Diamond is the hardest material known to man and therefore produces the sharpest edge. (Fig 2) Diamond blades can also be produced using lasers and acid to etch the edges. This technology was developed in Russia and is a more economical process. The major drawback is that these laser and acid etched blades cannot be re-honed and would need to be replaced if damaged. Both techniques produce an exquisitely sharp edge. Blade sharpness, in my experience, has obvious benefits; the sharper the blade the more control a surgeon has, there is reduced tissue trauma and the incisions are more reproducible.

Black Diamond is not diamond or synthetic diamond; it is a chemical vapor deposition (CVD). This technique along with the material used in the manufacturing process, produces a jagged edge verses a honed edge. (Fig 3) Creating an incision with this material is more of a sawing action rather then a cleaving action of a diamond.

Stainless Steel and the techniques used today in the manufacturing of the micro-surgical blades have made tremendous strides in sharpness and design over the last few years but there remains some variation in quality and consistency from blade to blade and from manufacture to manufacturer. These variations can be troublesome and potentially hazardous in surgery. As demonstrated by the Mohs Scale of Hardness, stainless steel lacks the primary attribute that enables a blade to have a superior edge. There is no doubt that the latest technology; coining and chemical etching, produces a far superior blade than grinding. The majority of the blades on the market today are produced by this process. The fact remains that regardless of the grade of stainless steel or the manufacturing technique, it will not produce a blade as sharp as a diamond.

Ceramics and ceramic composites are currently being developed that may or may not equal the edge sharpness of a diamond. Their limitation in the past has been their inability to be produced in designs that would lend themselves to micro-surgical blades.

Sharpness (Penetration)

In the design process, the hardness or rigidity of the material can affect mass, which in turn can affect penetration. Diamond, being the hardest material, lends itself to producing thin blades (less mass) while retaining rigidity. It is, however, limited by the fact that it requires wider facets to produce an edge than coined metal does. Diamond blades are between 150-200 microns thick. Because of the relative softness of the coined metal blades, they reach their minimum thickness at about 150 microns. Until a new material is developed the 150 micron threshold applies to most blades.

With the 150-micron limit equally in place we are left with a difference in geometry to create a better penetrating blade. Here again diamond has an advantage over other materials. Because of its sharper edge the angle of attack need not be as acute. Metal blades have to compensate by producing a more acute angle, which requires a longer blade. This means that with a diamond blade you have less blade entering the anterior chamber and thereby less chance of damaging adjacent ocular structures and greater margin of safety.

Blade geometry not only effects penetration, it also affects the geometry of the incision. In working with blade manufactures to design a blade that meets my requirements I developed with Ron Dykes of Diamatrix the 2.7X3.2mm trapezoid large bevel up small bevel down design. (Fig 4) The trapezoid geometry has gained widespread popularity. This blade geometry creates a smaller internal incision and a larger external incision. With this design, the wider external incision produces an oarlock effect that reduces stria during cataract removal and facilitates the introduction of instruments into the anterior chamber. The smaller internal incision promotes a more secure wound and stable anterior chamber. The bevel design creates a self-planing and self-sealing incision. I continue to use this design today with the exception of reducing the dimensions to 1.9 X 2.5 mm. (Fig 5)

Cost effectiveness of different materials

In today's current climate of reduced reimbursements, cost per case becomes a paramount issue. If the features and benefits of all blades were equal (which they are not), our choice could then be based solely on our cost per case. Using this premise and making some assumptions, let us look at the numbers for a keratome. The diamond keratome cost $2,800 X 3 = $ 8,400. Average one repair a year at a cost of $1,200. Total cost for the first year is $9,600. Using an average 2,000 cataracts a year brings the cost per case for the first year to $4.80 and $.60 per case for the following years. A premium single use metal keratome is $28.00. If you are able to get three uses, the average cost per case is $ 9.30. If the surgeon uses the blade more than three times, performance usually is reduced.

By using metal blades there is a potential $ 9,000 loss the first year and $17,400 for each of the following years. This same case can be made using other materials, which would yield similar results. The fact remains that "diamonds are forever."

Conclusion

In the final analysis, it is the musician, not the music that determines the level of excellence. Whichever blade design or material you choose to use in surgery should be determined by what works best for you and your patient. For me, it's still diamond.

References

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Legends

Figure 1 – Blades in Clear Corneal Construction Almost Square

Figure 2 – The Mohs Scale of Hardness

Figure 3 – Diamond and CVD Edge Comparison at 500X

Figure 4 – Williamson Trapezoid 2.5 X 2.9 Diamond Keratome

Figure 5 – Trap Design 1.9 X 2.5 mm