TECHNIQUE

Endothermal pupilloplasty to optimize pupil centration, size, and contour

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Iris defects and distorted pupils are commonly managed with iris suturing techniques that aim to close the defect and/or reform the physiological pupil. The re-creation of an optimally sized and centered pupil is often challenging because of missing iris, asymmetrical iris damage, or variable tension around the pupil. Current options include removing or cutting iris tissue using microscissors or the vitreous cutter, instrument stretching, or postoperative laser photocoagulation. Iris microendodiathermy is a simple technique that is minimally traumatic, titratable, and controlled, avoids excessive tissue manipulation, and is able to create a round cosmetically pleasing pupil. A bipolar endodiathermy cautery is applied to the iris stroma to induce tissue contraction and to gently pull the pupil in the meridian to which probe is applied. Endothermal pupilloplasty (EDP) may be used to recenter or enlarge a small pupil, thereby avoiding additional trauma inflicted by a vitrector or microscissors that physically cuts the iris.

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Online Video

Iris and pupillary abnormalities may occur from a variety of conditions, including trauma, congenital, proliferative, and iatrogenic causes. These defects can result in various issues including loss of visual acuity, increased optical aberrations, photophobia, glare, and night vision disturbances. Many of these symptoms can cause severe disability and significantly impact quality of life. In addition, the self-consciousness around having a distorted pupil can impact the patient psychologically with loss of confidence and self-esteem. Reconstruction of the iris and pupil provides an opportunity to address the visual, functional, and cosmetic issues for patients. This can be accomplished by direct closure of iris defects and pupil irregularities with sutures or with an iris prosthesis in cases where there is insufficient iris tissue.[1] Although challenging, we prefer to primarily repair the iris if sufficient iris tissue exists as this results in the most natural appearance of the eye.

The pupil plays an important role in ocular function, vision, light transmission, and cosmesis. The most pleasing aspects of a pupil are its centration, shape, roundness, and symmetry. Although the pupil is less likely to dynamically dilate and constrict with iris damage, with tissue loss, or after surgical repair, achieving a moderately sized pupil provides a good balance of visual, functional, and cosmetic symmetry with the fellow eye. In addition, this provides the ability to perform posterior segment examinations.

Iris defects are typically sutured with multiple 10-0 polypropylene sutures on a long curved needle to reappose the iris edges. The pupil is reformed using these sutures to best approximate its location. However, the achievement of a well-centered, round, and appropriately sized pupil is often challenging because of tissue loss and asymmetrical tension on the iris. Techniques to address the shape and size of the pupil include the use of microscissors or a vitreous cutter to cut iris tissue. However, there is suboptimal control with this technique and typically leads to irregular pupil margins, removal of tissue, and difficulty achieving optimal pupil centration and roundness. Postoperatively, laser photocoagulation may be used, but this lacks the same intraoperative control as a surgical technique.

We describe a new surgical approach to adjust a decentered pupil to achieve a more centered, round, and circular pupillary margin using bipolar microendodiathermy. Endothermal pupilloplasty (EDP) does not remove or cut iris tissue, elicits minimal inflammation, has a short learning curve, and is titratable and controlled. In our experience, this pupilloplasty approach provides excellent cosmetic outcomes when performed in combination with surgical repair of the iris.

SURGICAL TECHNIQUE

Our standard approach to iris defect repair consists of using 10-0 polypropylene sutures with a double-armed CIF-4 needle (Ethicon) to reapproximate and reconstruct the missing iris tissue. After the iris sutures are placed, we use iris cautery to refine the pupil centration and size. This technique consists of using a 23-gauge endodiathermy straight blunt tip bipolar cautery (Dutch Ophthalmic Research Center) (Figure 1) to

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Figure 1. A 23-gauge endodiathermy straight blunt tip bipolar cautery (Dutch Ophthalmic Research Center).

apply light cautery to the midiris stroma, which gently stretches the pupil in the meridian to which cautery was applied (Video 1 available at http://links.lww.com/JRS/A402). We recommend a bipolar as opposed to monopolar cautery for safety reasons and prefer more of a blunt tip rather than a sharp tip to avoid tearing or snagging tissue. The residual iris tissue is reshaped and functionally moved to the geometric center of the eye without removing any real tissue.

For a decentered pupil, diathermy is applied in a sectoral fashion to cause contraction of the iris tissue and gently pull the pupil in the direction to which cautery was applied, aiming for recentration (Figure 2). In cases of a small pupil, cautery can be applied circumferentially to enlarge the pupillary margin. Coagulation is used in a continuous linear fashion with zero% to 40% power and can be attached to a phacoemulsification machine. The degree of control is excellent, and the amount of tissue contraction will dictate how much the pupil is enlarged. This is controlled by the level of energy applied, duration of application, and, most significantly, distance from the pupil margin. The power level and duration is variable, and we recommend using lower power levels (less than 20%) and short application time (1 second) and increased as necessary based on visible tissue reaction. If the diathermy probe is applied at a distance closer to the pupil margin, more effect is achieved. Conversely, if it is used farther away, less effect is achieved. Thus, it is easy to control the pupil size and possible to adjust accordingly during surgery. We recommend initially applying cautery to the midiris stroma instead of an area closer to the pupillary margin to avoid any exaggerated pupil enlarging effects. From our experience, the degree of stromal contraction is greater in darker-colored than lighter-colored irides because of greater thermal absorption with greater pigmentation but can be effective in both.

The goal of this technique is to create and maintain an appropriate pupil size to alleviate symptoms while still permitting adequate light during scotopic conditions and allowing for an adequate posterior segment examination. Preoperative documentation of contralateral pupil size is helpful as a reference.

Caution should be exerted when applying cautery to areas of iris atrophy or thinning. In addition, it is best to apply cautery away from the suture knot as it may result in a broken suture; however, this is uncommon.

After applying cautery, attention should be paid to ensure that iris tissue is free from the cautery tip before removing it from the anterior chamber. Otherwise, an iatrogenic iris tear may result.

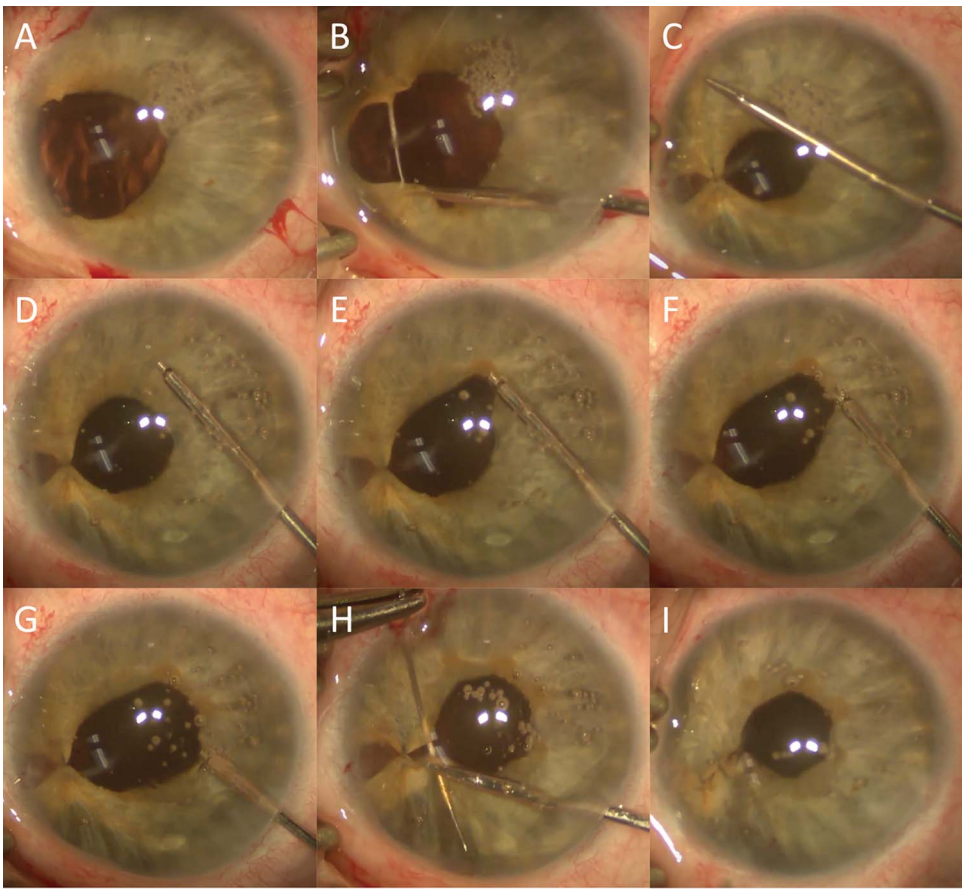

Figure 2. (*A*) Large decentered pupil. (*B*) Iris suturing using 10-0 polypropylene on a CIF-4 needle (Ethicon) to reappose the iris leaflets. (*C*) Tying the knot in a 3-1-1 fashion. (*D*) A 23-gauge bipolar endodiathermy cautery is applied to the peripupillary iris. (*E–F*) Pupil gently stretches in the meridian to which cautery was applied. (*G*) A more centered and larger pupil after Endothermal pupilloplasty is performed. (*H*) Additional iris sutures to reduce the final pupil size. (*I*) Final pupilloplasty results after Endothermal pupilloplasty is performed.

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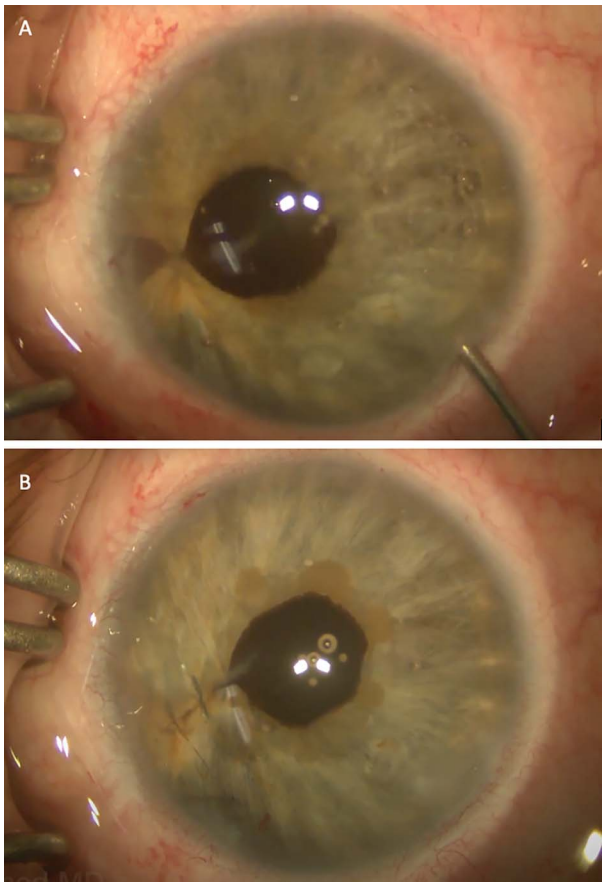

Figure 3. (*A*) Original iris color. (*B*) Subtle iris discoloration around the pupillary margin where cautery was applied.

When operating on a thin and atrophic iris, extra care should be taken to apply very light cautery as iris contraction induced by endodiathermy may result in new iris defects. Some minimal iris discoloration is expected, but this is often very subtle and visible only under the microscope (Figure 3).

Endodiathermy may be applied as many times as necessary to the peripupillary iris to achieve an ideal pupil shape and contour. We often alternate between suturing iris tissue and applying endodiathermy to carefully position the pupil. If the pupil aperture is too large or an iris gap remains after cautery, the pupil shape may be refined by returning to the suturing step and repeating the process to achieve a round and central pupil. In long-term postoperative follow-up, cautery application to the iris rarely regressed.

DISCUSSION

This article describes an additional step when performing pupilloplasty to improve the circular contour and position of the pupillary margin. In our practice, we often perform EDP for cases of decentered and corectopic pupils, irregular pupil shape, or small pupillary aperture secondary to traumatic iridodialysis or iris coloboma. Our clinical experience using this technique has yielded excellent results regarding visual, functional, and cosmetic postoperative outcomes. As there is no microcutting of the pupil margin as opposed to titratable contraction of peripupillary tissue with EDP, the pupil margin tends to retain its smoothness and avoids irregular edges. The

Figure 4. Photograph of an eye that underwent pupilloplasty and EDP 10 years ago, showing minimal regression of the EDP effect. EDP – endothermal pupilloplasty

cosmetic result is particularly notable with this technique in the ability to produce an exquisitely round, centered, and symmetrical pupil in our experience. This results in an improved self-esteem and quality of life for the patient. A well-centered, round, and reasonably sized pupil is of critical importance to the cosmesis of the eye, which should not be ignored and recognized as an important outcome of pupil repairs. Although there is no consensus on an ideal size, maintaining a pupil size of 3.5 mm provides a good balance of functional improvement but still permitting adequate examination of the posterior segment examination. Furthermore, when focal sutures are placed, the remainder of iris tissue is able to dilate.

To the authors' knowledge, this is the first description of EDP. Stopa and Rakowicz described a sutureless approach to the reapposition of iris tissue edges by using iris cautery instead of suturing to achieve a connection in cases of sectoral iris defects, traumatic mydriasis, and iridodialysis.[2] Xiang et al. described the use of radiofrequency diathermy to cut iris tissue and fibrous membrane in the pupil space.[3] Our technique adds an additional use to iris cauterization: to adjust iris tissue for pupillary centration and shape during pupilloplasty.

There are several advantages that EDP offers over current pupil reshaping techniques. First, it is an effective and simple strategy to avoid causing additional trauma to the iris. A vitrector or microscissors can cut and attempt to reshape the pupil; however, both consist of cutting or removing tissue and typically do not leave a smooth and circular pupillary margin. Scalloped, irregular, and noncircular edges often result. There is also a risk for further trauma and bleeding with cutting techniques. We did not observe intraoperative bleeding for any eyes in which this technique was used. Typically, this complication occurs because of excessive tissue manipulation or overstretching. EDP could possibly avoid these complications, introducing minimal instrumentation into the anterior chamber, thereby reducing trauma, potential endothelial damage, and risk for iatrogenic damage during surgery. If bleeding does occur, it can be easily controlled with the cautery probe.

A similar nonsurgical technique for adjusting pupil location and size is argon laser pupilloplasty.[4,5] This technique has been used postoperatively in eyes with a

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decentered multifocal intraocular lens to improve visual function.[4] It may also be used in combination with argon laser peripheral iridoplasty to relieve pupil block.[5] Although postoperative laser photocoagulation is an option, we do not find it as controlled as intraoperative adjustments. Furthermore, a greater effect can be obtained with endodiathermy, which can also be adjusted with additional sutures to refine the iris and pupil appearance.

Limitations of this technique include the unknown long-term stability of cautery-induced iris contraction. However, in our 10 years of experience, we have noted minimal regression in treated patients, although some depigmentation is expected (Figure 4). Unlike experiences with corneal coagulative procedures, iris coagulation does not seem to regress. Furthermore, coagulation may induce some inflammation, but this can be well controlled with early postoperative topical steroids. Finally, if the iris defect is too large, there may be insufficient tissue to reapproximate to reform the pupil and apply coagulation. In these cases, an iris prosthesis is likely more appropriate.[1]

EDP is a straight forward and minimally traumatic method to optimize pupilloplasty outcomes by improving pupil centration, size, and contour. It minimizes instrumentation and tissue manipulation in the anterior chamber to achieve excellent functional, visual, and cosmetic outcomes and can be readily accessible in most operating rooms.

WHAT WAS KNOWN

- Several pupilloplasty techniques exist for iris defect closure and iris edge reapposition.
- The functional and cosmetic outcome of iris defect repair is often not ideal, resulting in intolerable glare, photophobia, visual distortion, and poor cosmesis.
- More sophisticated techniques are required to address pupil centration, contour, and aperture size to optimize outcomes of pupil reconstruction beyond just iris defect closure.

WHAT THIS PAPER ADDS

- Although pupil defects are traditionally challenging to refine to adequate size, shape, and centration during suture repair, this study presents a titratable technique to restore a normal pupil size and contour without excessive manipulation, bleeding, or instrumentation.
- Endodiathermal pupilloplasty is a simple and effective strategy to recenter, enlarge, and shape the pupillary margin. It is minimally traumatic with less risk for endothelial and iatrogenic damage compared with using a vitrector or microscissors to remove excess iris tissue.
- This technique provides exquisite control to achieve a cosmetically pleasing pupil and iris repair, thereby improving the patient's quality of life.

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