Use of the Toric Surgical Marker to Aid in Intraoperative Plaque Placement for the USC Eye Physics Plaques to Treat Uveal Melanoma: A New Surgical Technique

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BACKGROUND AND OBJECTIVE: To describe a new surgical technique for intraoperative placement of Eye Physics (EP) plaques for uveal melanoma using a toric marker.

PATIENTS AND METHODS: A toric marker is designed for cataract surgery to align the axis of astigmatism; its use was modified in this protocol to mark the axis of suture coordinates as calculated by Plaque Simulator (PS) software.

RESULTS: The toric marker can be used to localize suture coordinates, in degrees, during intraoperative plaque placement. Linear marking using the toric marker decreases potential inaccuracies associated with the surgeon estimating 'clock-hours' by dot placement.

CONCLUSION: Use of the toric marker aided surgical placement of EP plaques. The EP planning protocol is now designed to display the suture coordinates either by clock-hours or degrees, per surgeon preference. Future research is necessary to determine whether routine use of the toric marker improves operative efficiency.

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INTRODUCTION

Various surgical techniques have been described to increase the accuracy of plaque localization during brachytherapy for uveal melanomas. These include scleral transillumination, indirect ophthalmoscopy with scleral depression, scleral diathermy, and ultrasonographic confirmation of plaque localization.[1] A preoperative method for plaque localization using the University of Southern California (USC) Eye Physics (EP) plaques and Plaque Simulator (PS) software has been described previously.[2-7] The EP plaques are designed to provide a conformal dose of radiation to the tumor while sparing other critical ocular structures whenever possible. The long-term results from treating medium-sized choroidal melanomas with EP plaques are comparable to the Collaborative Ocular Melanoma Study (COMS) plaques: the local recurrence rate was found to be 2.4% with this method during a 20-year period.[7] An additional benefit of EP plaques is that the PS software allows for preoperative treatment planning and plaque localization, minimizing intraoperative time required for plaque placement. This is done by providing the surgeon with two coordinates that correspond to the anticipated location on the sclera for suture placement, as well as a distance between the two suture points called the inter-eyelet distance (Figure 1). In the EP

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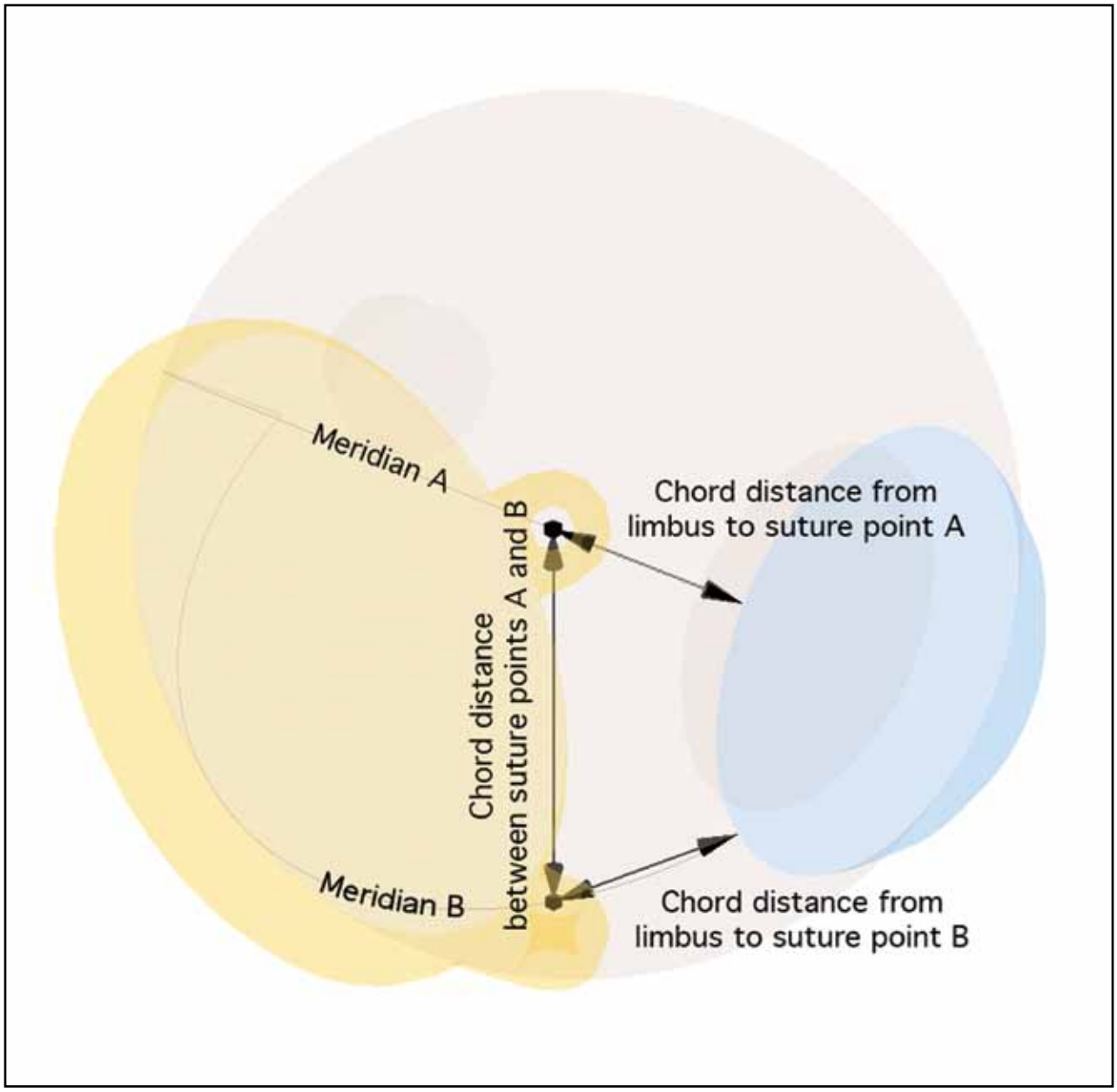

Figure 1. Plaque localization. The Plaque Simulator planning protocol provides two chord distances to suture points A and B that are measured from the limbus to the predetermined point on the sclera for suture placement. The two sutures hold the plaque in place on the sclera. A third distance, the inter-eyelet distance, is also given, which serves as an internal control. This distance between the suture coordinates should match the distance between the eyelets on the plaque.

plaque system, two intrascleral sutures are used to secure the plaque to the eye wall. Such coordinates were previously given in clock-hours for the meridian and a chord distance, in millimeters from the limbus to the suture coordinates.[7] This technique required the surgeon to estimate clock-hours around the limbus of the eye (often very specifically, and with minute increments such as 9:12 and 12:56).

The toric surgical marker was created for intraoperative use in cataract extraction in combination with intraocular toric lens placement to correct regular astigmatism; there are various shapes and sizes on the market. With appropriate marking, the margin of error in toric intraocular lens placement has been shown to be less than 10°, and multiple studies have documented the accuracy of toric surgical markers.[8] A new surgical technique using a toric marker for intraoperative plaque localization is described in this report.

Figure 2. Toric marker for intraoperative localization of episcleral plaques. (A) The toric marker is aligned to the axis recommended by the plaque planning protocol and surgical marker is placed on the instrument. (B) A 90° mark is placed on the cornea in the preoperative area to be used as a reference; this mark is used to align the toric marker. (C) A marked eye showing the 90° reference point (which was marked preoperatively) and two linear marks on the sclera representing the two meridians required for suture placement for plaque eyelets.

PATIENTS AND METHODS

Between March 1 and December 1, 2014, 10 patients were treated with Iodine-125 plaque brachytherapy for medium-sized choroidal melanomas (as per COMS nomenclature) using the EP plaques and the PS software for preoperative plaque planning. A toric marker was used intraoperatively to aid plaque placement for all patients.

The details of the PS software for treatment of these patients has been described previously.[7] In brief, a virtual model of the eye and tumor are used to select a plaque, identify the appropriate seed positions and strengths that conform to the tumor base, and calculate the resulting dose distribution. The location, orientation, size and shape of the plaque, and strength of the seeds are selected so as to envelop the tumor apex, longest basal diameter, and a 2-mm retinal margin surrounding the base within a prescribed isodose surface (ie, 85 Gy to the tumor apex).

In the previous description of our surgical procedure,[7] suture coordinates for plaque eyelets were expressed as a retinal map meridian (clock-hours and minutes) and chord distance from the limbus (Figure 1). Our new surgical technique and PS planning describes the suture coordinates for axis in degrees; the chord distance from the limbus is calculated in millimeters, as before.

In the preoperative area a reference mark is made on the limbus of the operated eye at the 90° meridian with the patient sitting upright. Intraoperatively, a 180° peritomy is performed taking care to not disturb the reference mark. Once hemostasis is maintained with bipolar cautery, a surgical toric marker (Duckworth & Kent Cionni Toric Axis Marker model 9-841; Baldock, England) (Figure 2) is used to create two linear marks at the limbus for the two suture coordinates; the 90° mark made preoperatively is used as a reference guide for the toric marker. The two scleral marks are then made at the prescribed chord distance from the limbus.

Once the marks are in place on the sclera for suture placement, the inter-eyelet distance is also measured. The inter-eyelet provides an internal control, as this distance measured on the sclera should match the distance between the plaque eyelets, as well as the distance given on the PS planning protocol. The remainder of the surgical technique then proceeds as previously described.[7] Two sutures are preplaced in the sclera, and a "dummy" (unloaded) plaque with the same design as the "treatment" plaque is temporarily secured in position on the sclera. Correct plaque placement is further confirmed with via indirect ophthalmoscopy and scleral depression around the plaque to ensure the tumor base is centered under the plaque with equal, 2-mm margins. Once the position of the plaque is confirmed, the dummy plaque is removed and the treatment plaque that is loaded with radioactive Iodine-125 seeds is secured to the eye wall using the same preplaced sutures.

RESULTS

The toric surgical marker was used successfully to localize suture coordinates for EP plaque eyelets in 10 patients with uveal melanomas between March 1 and December 1, 2014. The PS software was able to display the suture coordinates either in degrees as described herein or in 'clock-hours' as described previously (Figure 3). Two additional surgical steps confirmed the accuracy of plaque placement. First, the PS software provides the inter-eyelet distance, which should correspond to the distance between the preplaced sutures. Funduscopy with indirect ophthal-

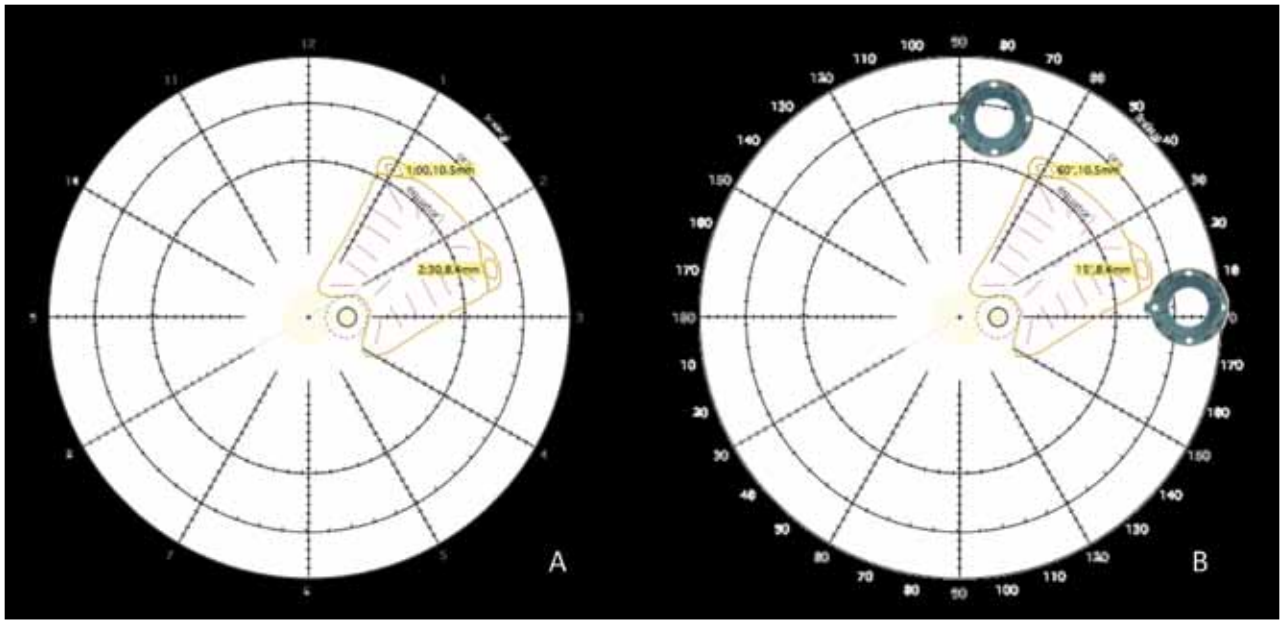

Figure 3. Plaque planning protocol options. Per surgeon preference, the suture coordinates can be presented in 'clock-hours' or axis and millimeters from the limbus. The chord distances and the inter-eyelet distance (not shown) are the same regardless of preference.

moscopy was also performed to ensure the plaque was centered over the tumor base with appropriate margins on each side.

Although our previously published results using clock-hour coordinates demonstrated excellent treatment outcomes, there is potential inaccuracy in a surgeon manually marking clock-hours on the globe. This is especially the case if the PS calls for very particular clock-hour coordinates with minutes such as 8:47 or 11:04. Additionally, these initial clock-hour marks are points and then a linear, longitudinal meridian mark must be estimated from this point. The toric surgical marker creates a linear mark at the limbus so there is no ambiguity regarding the longitudinal meridian along which to place the sutures for the plaque eyelets. Although rare, the inherent inaccuracy in 'clock-hours' would occasionally require the surgeon to remark the eye if the inter-eyelet distance, which is an internal control, did not match or to reposition the plaque if it was not well-centered over the tumor on indirect ophthalmoscopy.

Since the institution of the toric surgical marker to guide EP plaque placement in our protocol, no plaques have required intraoperative readjustment and the inter-eyelet distance was correct at the first measurement in all cases. The placement of the plaque on the sclera overlying the tumor was judged to be appropriate by the surgeons (JB, JK) in all cases when confirmed by indirect ophthalmoscopy. There were no intraoperative complications, and the operating time was not increased. The average time of follow up was 9 months and ranged between 6 and 15 months for these cases. There have been no cases of local recurrences, and in all patients at last follow-up, the tumors demonstrated regression, indicating appropriate plaque placement.

DISCUSSION

Herein we describe a new surgical technique adapting the toric marker for use in episcleral plaque brachytherapy. In our hands, use of the toric marker aided surgical placement of EP plaques. The axes for suture coordinates were efficiently and accurately marked. The linear nature of the marks facilitated caliper measurement (in millimeters) along the marked longitudinal meridian to the point of suture placement.

The PS plaque planning protocol for EP plaques is now designed to display the suture coordinates either by clock-hour or degrees, and either method can be used to localize the plaque (Figure 3). Prior to use of the toric marker, the initial scleral marks occasionally needed to be adjusted because the inter-eyelet distance did not correspond or the plaque required intraoperative readjustment (surgeons' personal experience). However, since implementing use of the toric surgical marker in this case series, neither the initial marks nor the plaques required readjustment, as all were considered appropriately localized by the surgeons.

The cohort of patients treated with the toric marker is too small and the follow-up time is too short to make any significant comments about surgical efficiency and tumor control. However, given the plaque

placement was confirmed to be accurate intraoperatively in all cases, we do not expect any long-term changes to rates of local tumor control. Additionally, at the last follow-up visit all tumors were showing appropriate early tumor regression post brachytherapy.

Many methods exist for appropriate plaque localization during brachytherapy. The toric surgical marker is another tool that may aid the ocular oncologist in attaining accurate placement of EP plaques with PS planning protocols. Future research is necessary to determine whether use of the toric surgical marker improves operative time and efficiency.

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