Chapter 11
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Radiowave-Assisted Iridocyclectomy for Anterior Uveal Melanoma: A 13-Year Clinical Study

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Abstract

Background: Uveal melanoma is a highly malignant tumour of the eye, which is characterised by melanocytic tumour growth within the uveal tract of the eye. There is a nearly equal distribution of primary uveal melanoma gender. The management options include transpupillary thermotherapy, brachytherapy, stereotactic radiotherapy, limited surgical resection, enucleation and orbital exenteration. Complications in the surgical removal of pre-equatorial tumours are largely technique-related and may be reduced by combining tumour resection with simultaneous vessel coagulation using radiowave surgery.
Purpose: The aim of this study is to determine the efficacy of resecting iris and ciliary body melanoma with the use of a 3.8-4.0-Mhz radiowave surgery unit.
Methods: This study was carried out at the Department of Eye Cancer, the Filatov Institute, between 2005 and 2018 and included 45 patients with iris and ciliary body melanoma, with a mean age of 56.3 ± 2.2 years and a slight predominance of female patients (53.3%). Sixty-seven patients who had undergone iridociliary melanoma excision using a conventional technique with cutting tools were used as retrospective controls. The eye examination included visual acuity measurement, perimetry, biomicroscopy and ophthalmoscopy. Tumour, nodus и metastasis (TNM) staging was according to the American Joint Committee on Cancer (AJCC). No metastases were seen at the time of enrollment. The mean tumour prominence at baseline was 4.0 ± 0.3 mm, with a mean base diameter of 8.3 ± 0.4 mm, corresponding to a tumour volume of

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34.3 ± 0.7 mm^3. Patients in both groups were stratified by baseline visual acuity into two subgroups (0.1–0.5 and 0.6–0.8). In the study group, subgroup 1A included 37 patients (82.2%) with visual acuity of 0.1–0.5, while subgroup 1B comprised 8 patients (17.8%) with visual acuity of 0.6–0.8, and in the retrospective control group, subgroup 2A consisted of 55 patients (82.1%) with visual acuity of 0.1–0.5, and subgroup 2B included 12 patients (17.9%) with visual acuity of 0.6–0.8 ($p > 0.05$). The analysis was performed by analysis of variance (ANOVA) using Statistica 13.0 (Dell Statsoft Inc., Austin, TX).

Results: The radiosurgical approach to treatment of iridociliary tumours in our patients allowed significantly reducing the rates of intraoperative and postoperative complications ($\chi 2$=4.16; df=1; p=0.04). In addition, the rates of intraoperative and postoperative complications for the treatment of iridociliary tumours with cutting instruments were 9.1% and 10.4%, respectively. The use of a radiowave surgery unit for uveal melanoma resection allowed preserving baseline visual acuity in all patients, with a tumour recurrence rate of not more than 2.2%.

Conclusion: The use of a radiowave surgery unit for uveal melanoma resection allowed preserving baseline visual acuity in all patients. Early (12-month) treatment outcomes (visual functions and postoperative clinical course) and late treatment outcomes (visual functions; optic media; IOP; and tumour recurrence) for iridociliary melanoma resection using a radiowave 3.8-4.0 MHz unit allow us to state that high-frequency radiowave surgery enables reducing the risk of intraoperative and postoperative complications and, consequently, preserving a good visual function.

Keywords: Uveal melanoma; radiowave surgery unit; treatment.

1. Introduction

Uveal melanoma is a highly malignant tumour of the eye that arises in the uvea. The word “melanoma” comes from the Greek word for black (μελας) and the suffix -ωμα, which indicates swelling, and was first introduced by Carswell in 1838 to describe any type of black discolouration (Gelmi & Jager, 2024). with a global annual incidence of more than 7,000 cases, and a mean age-adjusted incidence of 4.3 per million (Aronow et al., 2018; Papastefanou & Cohen, 2011). There is a nearly equal distribution of primary uveal melanoma by gender (Papastefanou & Cohen, 2011, Hamza et al. 2024). Caucasians and Hispanic Americans represent 98% and 1%, respectively, of cases in the US, and the rest (<1%) is attributed to American Asians, Africans and Native Americans (Maletskiy & Khomiakova, 2020). There is an average of 9.5 cases per million of UM in Ireland and other Northern European countries each year (Hanratty et al., 2025). Despite its rarity, uveal melanoma carries a significant clinical burden due to its aggressive metastatic potential (Bai et al., 2023). Colorectal and liver metastasis are the leading causes of death in Uveal melanoma patients (Shatnawi et al., 2025). It comes with a psychosocial burden on affected patients, with a great impact on their quality of life (Kulbay et al., 2024). The disease is most commonly diagnosed in individuals aged 50-60 years (mean age, 55 years) (Aronow et al., 2018; Papastefanou & Cohen, 2011). The age-adjusted incidence

increases with increasing age until about age 70-75, then plateaus (Aronow et al., 2018). Approximately 90% of uveal melanomas arise in the choroid, 6% in the ciliary body, and the remaining 4% in the iris (Papastefanou & Cohen, 2011). Iris melanomas are usually discovered in an early phase and have a favourable outcome, whereas ciliary body melanomas have a poor prognosis. Frequent mutations in the BAP1 (i.e., BRCA-1 associated protein 1), EIF1AX (i.e., eukaryotic translation initiation factor 1A X-linked), GNA11 (i.e., guanosine nucleotide-binding protein alpha-11), GNAQ (i.e., guanosine nucleotide-binding protein Q), and SF3B1 (i.e., splicing factor 3b subunit 1) genes were shown to occur in the majority of Uveal melanoma cases, as well as contribute on different levels to the metastatic risk (Kulbay et al., 2024). Uveal melanoma is often diagnosed incidentally, with approximately 30% of patients being diagnosed during routine ophthalmologic examination (Ziogas et al., 2025; Shields, 2025.

Therapy for uveal melanoma depends on the site and size of the tumour, course of the disease, fellow eye status, and the patient's systemic status (Maletskiy & Khomiakova, 2020). In addition, the therapeutic approach is tailored to the needs of the individual. Management options include transpupillary thermotherapy, brachytherapy, stereotactic radiotherapy, limited surgical resection, enucleation and orbital exenteration (Shields et al., 2015, Yang et al., 2018).

Surgical removal of pre-equatorial tumours may be associated with peri-operative complications (like expulsive haemorrhage, partial vitreous haemorrhage, and retinal detachment) and post-operative complications (cataract, ocular subatrophy, etc.) (Shields et al., 2015; Kim et al., 2017).

On the basis of the analysis of complications in the surgical removal of pre-equatorial tumours, we concluded that they are caused by the surgical technique itself. First, tumour resection using cutting tools may be associated with haemorrhage, which is difficult to control. Second, combining tumour removal with simultaneous local brachytherapy increases a therapeutic load on the eye, leading to ocular hypotony and subsequently to ocular subatrophy (Kim et al., 2017).

Given the above, it appears that the rate of these complications may be reduced if tumour resection is combined with simultaneous vessel coagulation with a radiowave surgery unit (Chua & Aplin, 2018). This will allow not only reducing the traumatic effect on the eye but also meeting the principles of ablastics (prevention of intraoperative dissemination of tumour cells) and reducing the risk of intraoperative haemorrhage (Maletskiy & Khomiakova, 2020).

While implementing the outlined technology for organ-preserving management of iridociliary melanoma, we encountered some issues for which we have failed to find appropriate solutions in the literature. In addition, the literature is scant on the use of RF surgery in uveal melanoma, and there is no data on appropriate modes for an RF surgery unit in manipulation of the sclera, iris, ciliary body and choroid. Findings of our previous experimental study (Khomiakova et al., 2019) have demonstrated that this approach is promising for the treatment of uveal melanoma, and encouraged us to further research.

The purpose of the study was to determine the efficacy of resecting iris and/or ciliary body melanoma with the use of a 3.8-4.0-Mhz radiowave surgery unit.

2. Materials and Methods

This study was conducted at the Department of Eye Cancer, the Filatov Institute, from 2005 through 2018.

The study group involved 45 patients with iris and ciliary body melanoma; the mean age was 56.3 ± 2.2 years, with a slight female predominance (53.3%). Sixty-seven patients who had undergone iridociliary melanoma excision using a conventional technique with cutting tools were used as retrospective controls. There was no significant difference in age, male/female percentage, visual acuity, or intraocular pressure (IOP) (Maletskiy & Khomiakova, 2020).

The set of diagnostic procedures adhered to the clinical guidelines from the Ministry of Health Order “On Approval of Protocols for Provision of Medical Care to Patients with Eye Disease” (Ministry of Health of Ukraine, 2007).

The eye examination included visual acuity assessment, perimetry, biomicroscopy and ophthalmoscopy. Tumour, nodus и metastasis (TNM) staging was according to the American Joint Committee on Cancer (AJCC) (Shields et al., 2015).

No metastases were seen at the time of enrollment. The mean tumour prominence at baseline was 4.0 ± 0.3 mm, with a mean base diameter of 8.3 ± 0.4 mm, corresponding to a tumour volume of 34.3 ± 0.7 mm^3 (Maletskiy & Khomiakova, 2020).

3. Operation Technique

An eye speculum was placed in the eye after preoperative showering with chlorhexidine. The scleral conjunctival incision was made 2-4 mm (depending on exact tumour location) outside the limbus at the tumour site, and the scleral conjunctiva was separated. Scleral projection of the tumour was clarified based on the data obtained from near-infrared transillumination, and the sector of exact tumour location was marked. Scleral incision was performed in a layer-by-layer fashion. A 3.8-Mhz radiowave surgery unit (Surgitron, Ellman International) was used to remove the tumour with 2-3 mm normal adjacent tissue margins in patients of the study group (Maletskiy & Khomiakova, 2020). The unit was set to 35 W in the coagulation mode and to 70-90 W in the cut mode to perform vessel coagulation and tissue dissection, respectively. Interrupted sutures were used to close the scleral incision, the anterior chamber was washed with Ringer solution, and the conjunctiva was closed using an uninterrupted silk suture. Patients received disinfectant eye drops, parabulbar antibiotic and steroid injections and aseptic dressing.

Antibacterial and anti-inflammatory therapy was used postoperatively. Prospective follow-up duration was from 12 months to 13 years (median value, 3.5 years) (Maletskiy & Khomiakova, 2020).

All the patients of each group were divided into two subgroups based on baseline visual acuity. The study group involved subgroup 1A (n=37 patients; 82.2%) with a visual acuity of 0.1 to 0.5 and subgroup 1B (n=8 patients; 17.8%) with a visual acuity of 0.6 to 0.8. The retrospective control group involved subgroup 2A (n=55 patients; 82.1%) with a visual acuity of 0.1 to 0.5 and subgroup 2B (n=12 patients; 17.9%) with a visual acuity of 0.6 to 0.8.

The analysis was performed by analysis of variance (ANOVA) using Statistica 13.0 (Dell Statsoft Inc., Austin, TX) (Rebrova, 2002). The tumour volume was calculated using the formula for a rotation ellipsoid:

$$V=4\pi ab2/3,$$

Where

a is the tumour prominence, and b is half of the tumour base diameter.

Mean (M), median (Me), quartile (q_1, q_3), mean root square deviation (σ) and standard error of mean (m) values were calculated. Non-parametric methods were used for group comparisons. The level of significance $p \leq 0.05$ was assumed (Maletskiy & Khomiakova, 2020).

4. Results

No intraoperative complications were observed in the study group.

In the early postoperative period (24 hours), one patient (1.4%) of this group exhibited local retinal detachment that was absent at the 4-month follow-up. In addition, two patients were diagnosed with hyphema. The condition was subject to routine treatment, and the two patients demonstrated no sequelae of this complication at the last follow-up visit (Maletskiy & Khomiakova, 2020).

With regard to the control group, vitreous haemorrhage was the most common postoperative complication (7 patients; 10.5%), followed by retinal detachment (4 patients; 5.7%) and epiretinal fibrosis (1 patient; 1.5%).

Therefore, the use of a radiowave surgery unit for melanoma resection in the study group allowed a significant decrease in the risk of postoperative complications compared with retrospective controls ($\chi2=4.46$, $df=1$, $p < 0.05$).

With regard to the study group, mixed melanoma was the most common histological tumour type (23 patients; 51.1%), followed by spindle cell A melanoma (7 patients; 15.5%), spindle cell A-B (6 patients; 13.3%), spindle cell B melanoma (5 patients; 11.1%), and epithelioid cell melanoma (4 patients; 8.9%). This is in agreement with findings reported by others (Shields et al., 2015).

No significant decrease in vision was found in both groups within a year after surgery (Fig. 1) (Maletskiy & Khomiakova, 2020). Although there was some decrease in visual acuity at 10-day, 3-, 6- and 12-month follow-up visits, no critical decrease in visual acuity was observed in any case. Mean visual acuity in the study group was 0.32 ± 0.02 at 10 days, 0.31 ± 0.03 at 3 months, 0.32 ± 0.02 at 6 months and 0.34 ± 0.03 at 12 months (Fig. 2) (Maletskiy & Khomiakova, 2020).

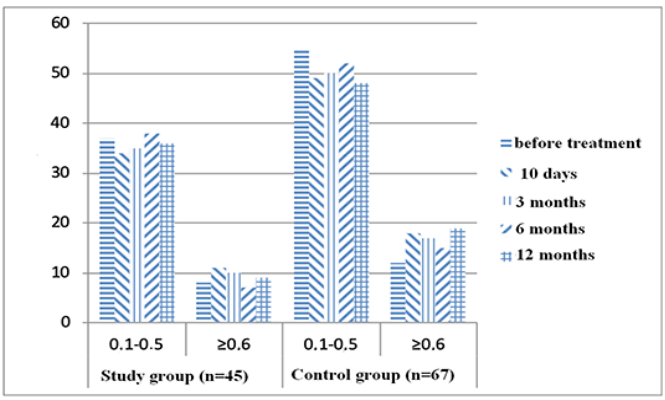

Fig. 1. Number of iridociliary melanoma patients with different categories of visual acuity at various time points from immediate post-surgery to 12 months

Note: The Y axis displays the number of patients and the X axis displays visual acuity

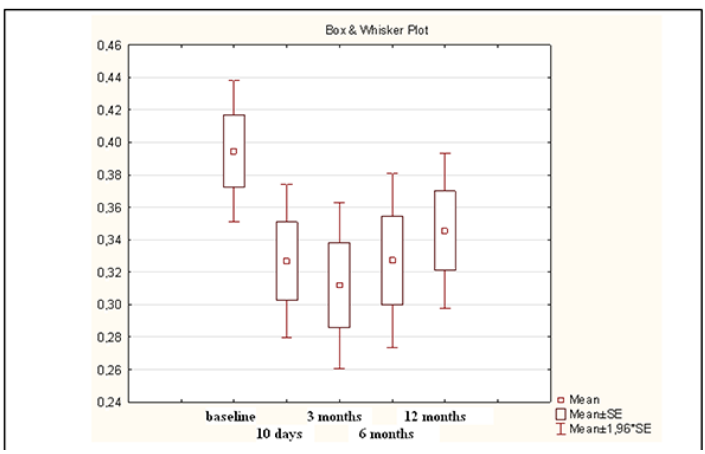

Fig. 2. Visual acuity in iridociliary melanoma patients at various time points

Note: The X axis displays time points, and the Y axis displays visual acuity

The use of a radiowave surgery unit allowed preserving baseline visual acuity over a year after surgery.

With regard to the retrospective data for controls, only visual acuity data for the hospital stay period were available, and mean visual acuity at discharge was 0.33±0.03, which was comparable with the results for the study group (Maletskiy & Khomiakova, 2020).

Of the nine study group patients with poor IOP control at baseline, only one (11.1%) showed high IOP at 12 months. Therefore, the use of a radio-wave surgery unit for uveal melanoma resection allowed normalising IOP in 88.9% of cases. All patients of the study group were still alive at 5 years, whereas of the 67 retrospective controls, 16 (23.9%) were found legally dead, and survival status was not available in 12 (17.9%) at 5 years. We believe that this difference may be explained by decreased dissemination of tumour cells in patients who underwent uveal melanoma resection using a radiowave surgery unit.

As it has been reported that the five-year survival rate for patients with metastasis-free uveal melanoma was approximately 75% (Aronow et al., 2018; Papastefanou & Cohen, 2011), the rate for our patients with uveal melanoma may be considered satisfactory.

Below, we present representative clinical examples of iridociliary melanoma treated using a radiowave surgery unit (Maletskiy & Khomiakova, 2020).

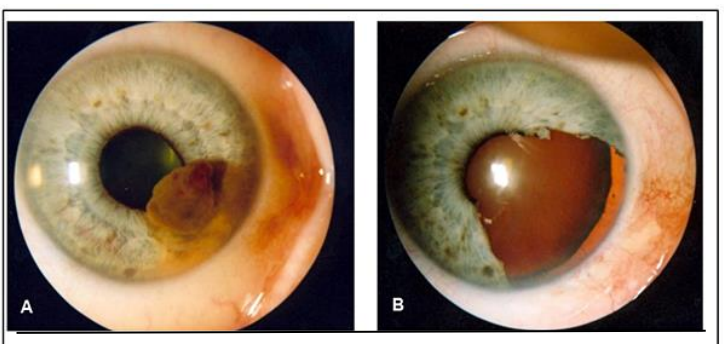

Fig. 3. Clinical example 1 (a 64-year-old patient). Photographs of the affected eye before (a) and after (b) surgery AB

Clinical example 1 (patient Mr U-ts, 64 years old, medical record No. 345672)

The diagnosis was an iridociliary melanoma OD, and the tumour was classified as a T1 N0 M0.

Clinical description: OD: A pigmented iris lesion involving the ciliary body, extending from 3 to 5 o'clock. The tumour base and thickness measured 5.6 x 6.0 mm and 4.1 mm, respectively, by ultrasonography. Preoperative visual acuity was 0.8 (Fig. 3a). The patient had iridocyclectomy with the use of a Surgitron radiowave unit. Histopathologic examination revealed a spindle A-B cell iris melanoma with involvement of the ciliary body. No complications were observed within the course of treatment. Postoperative visual acuity was 0.8 (Fig. 3b) (Maletskiy & Khomiakova, 2020). No recurrence was observed during a follow-up of 7 years and 8 months.

Clinical example 2 (patient Mr M-r, 49 years old, medical record No. 352632)

The diagnosis was an iridociliary melanoma OD, and the tumour was classified as a T1 N0 M0.

Clinical description: OS: A pigmented iris lesion involving the ciliary body, extending from 3 to 5 o'clock. The tumour base and thickness measured 3.5 x 4.0 mm and 2.1 mm, respectively, by ultrasonography. Preoperative visual acuity was 1.0 (Fig. 4a) (Maletskiy & Khomiakova, 2020). The patient had iridocyclectomy with the use of a Surgitron radiowave unit. Histopathologic examination revealed a spindle A-B cell iris melanoma with involvement of the ciliary body. No complications were observed within the course of treatment. Postoperative visual acuity was 1.0 (Fig. 4b). No recurrence was observed during a follow-up of 6 years and 5 months.

Fig. 4. Clinical example 2 (a 49-year-old patient). Photographs of the affected eye before (a) and after (b) surgery

The recurrence rate was 13.4% (9) in the control group and 2.2% (1) in the study group ($\chi 2=4.16$; df=1; p=0.04).

5. Discussion

In the current study, the radiosurgical approach to treatment of iridociliary tumours in our patients allowed significantly reducing the rates of intraoperative

and postoperative complications (?2=4.16; df=1; p=0.04). In addition, the rates of intraoperative and postoperative complications for the treatment of iridociliary tumours with cutting instruments were 9.1% and 10.4% (Rebrova, 2002), respectively, versus 3.6% and 7.5%, respectively, reported by others (Aronow et al., 2018; Smoliakova et al., 2006).

Moreover, the use of a radiowave surgery unit for uveal melanoma resection allowed for preserving visual acuity outcomes over a year after surgery in all patients. The tumour recurrence rate in the study group was 2.2%, which was significantly ($p < 0.05$) lower than in the control group (Maletskiy & Khomiakova, 2020).

Early (12-month) treatment outcomes (visual functions and postoperative clinical course) and late treatment outcomes (visual functions; optic media; IOP; and tumour recurrence) for iridociliary melanoma resection using a radiowave 3.8-4.0 MHz unit allow us to state that high-frequency radiowave surgery enables reducing the risk of intraoperative and postoperative complications and, consequently, preserving a good visual function.

6. Conclusion

First, the use of a radiowave surgery unit for uveal melanoma resection allowed for preserving baseline visual acuity in all patients.

Second, the 24-month tumour recurrence rate was not more than 2.2% in the group of patients treated with the use of a radiowave surgery unit.

Third, with regard to patients treated with the use of a radiowave surgery unit, the rate of postoperative complications was not more than 4.4%, and no intraoperative complications were observed (Maletskiy & Khomiakova, 2020).

Fourth, iridociliary melanoma resection using a radiowave surgery unit allowed normalizing IOP in 88.9% of patients with manifestations of secondary glaucoma.

Fifth, low complication and recurrence rates and improved 5-year survival rate allow us to recommend radiowave surgery as a surgical part of management of uveal melanoma.

Finally, since patients who underwent uveal melanoma resection using a radiowave surgery unit exhibited a 100% survival rate at follow-up ranging to 13 years, it is likely that this approach prevents intraoperative dissemination of tumour cells.

Consent and Ethical Approval

It is not applicable.

Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during the writing or editing of this manuscript.

Competing Interests

Authors have declared that no competing interests exist.

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