Clinical Outcome of Eye-preserving Treatment with Ruthenium-106 Brachytherapy for Choroidal Melanoma

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Clinical Outcome of Eye-preserving Treatment with Ruthenium-106 Brachytherapy for Choroidal Melanoma

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ABSTRACT

Clinical outcome of eye-conserving treatment with Ruthenium-106 brachytherapy for choroidal melanoma

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Purpose: In our institution, patients with choroidal melanoma have been treated with ruthenium-106 (Ru-106) brachytherapy with or without additional local therapy since 2006. The aim of this study is to report early clinical outcomes of eye-preserving treatment strategy for choroidal melanoma of variable size

Patients and methods: Ninety-three consecutive patients diagnosed of uveal malignant melanoma were treated with Ru-106 brachytherapy between October, 2006 and December, 2012. Patients with iris and ciliary body tumor were excluded (n = 5), leaving 88 patients for analysis. In our institution, malignant melanomas of variable

size were treated with Ru-106 brachytherapy and most of the medium to large sized tumor (height ≥6 mm) received combined therapy adding local excision and/or transpupillary thermotherapy (TTT). In general, 85-95 Gy was prescribed to the apex of the tumor for patients without local excision, and 100 Gy to the 2-mm point from the outer surface of the sclera for patients undergoing tumor excision.

Results: Median follow-up was 30 months. The median age of all cohort was 50 years (range 19-82 years). Median basal diameter was 11.4 mm (range 2.96-17.28 mm) and tumor height was 6.79 mm (range 1.73-13.66 mm). The actuarial 3-year local control rate was 80%. Distant metastases were diagnosed in 12 patients and a total of 11 patients died. Actuarial metastases-free survival rate was 84% and overall survival rate was 90.3% at 3 years. Among the 88 patients, 13 patients eventually underwent enucleation, resulting in a 3-year eye-preservation rate of 80%: 12 patients underwent enucleation for local recurrence and 1 for complication. Significant prognostic factor for eye-preservation rate was tumor height (p = 0.042). The number of patients with tumor height ≥6 mm was 50 (57%) and additional local therapy was used in the treatment of 94% (n=47) of these patients. Three-year eye-preservation rate was 94% for tumor height <6 mm, and 70% for tumor height ≥6 mm (p = 0.047). Only 1 patients with tumor size <6 mm (n = 38) experienced distant metastasis and eventually died of disease.

Conclusion: Ru-106 brachytherapy for choroidal melanoma of variable size showed favorable outcome. Additional local treatment may improve eye preservation rate in

medium to large size tumor.

Key words: choroidal melanoma, brachytherapy, eyeplaque, ruthenium-106, enucleation

Clinical outcome of eye-conserving treatment with Ruthenium-106 brachytherapy for choroidal melanoma

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I. INTRODUCTION

Choroidal melanoma is the most common primary intraocular malignancy in adults. In Korea, about 20 cases are reported annually. Until the introduction of plaque brachytherapy using iodine-125 (I-125) in the 1960s, enucleation had been a standard treatment for patients with choroidal melanoma. Although the most important treatment aim is survival free of disease recurrence, both patients and clinicians focus on the preservation of function and cosmetic appearance as well.

The Collaborative Ocular Melanoma Study (COMS) confirmed the efficacy of plaque brachytherapy in a multicenter randomized trial including 1317 patients, which did not show any inferiority of I-125 brachytherapy to enucleation showing comparable 5-year overall survival (81% vs. 82 %) or 5-year cancer specific survival (89% vs. 91%).[1,2] Today, brachytherapy has assumed a major modality in the management of choroidal melanoma since it is considered an equivalent eye-preserving alternative to enucleation. Although the benefit of eye preservation may be reduced by impaired vision resulting from radiation toxicity, eye-preserving brachytherapy has major functional and cosmetic advantages.

Since its introduction, Ruthenium-106 (Ru-106) brachytherapy has been increasingly used for treatment of small to medium choroidal melanomas.[3-5] Ru-106 brachytherapy with 1000 Gy to the base conveys less than 100 Gy to 7 mm from the base, giving insufficient radiation dose to apex of large tumor.[6,7] Insufficient radiation to the apex delivered by Ru-106 could reduce local tumor control rate and increase the risk of recurrence, as well as metastases and mortality. Several studies have reported outcome of the combination of the brachytherapy and transpupillary thermotherapy (TTT).[8,9] This combination therapy was introduced to enable eye-preservation for patients with tumors thicker than 5 mm. Or, on the other end, this strategy was used to lessen radiation dose for smaller tumors to reduce the risk of radiation related toxicities. Moreover, patients with insufficient tumor regression after brachytherapy or with recurrent tumor can be re-treated with TTT.

Before the introduction of Ru-106 plaques (Eckert & Ziegler BEBIG, Berlin, Germany) to our institution in October 2006, GKS (Gamma knife surgery) using a Leksell γ-knife (Elekta Instruments AB, Stockholm, Sweden) was the only eye-sparing treatment for choroidal melanoma available in Korea. After Ru-106 plaques became available, we primarily performed brachytherapy with additional local treatment including TTT and local excision as an eye-preserving therapy for choroidal melanoma. The aim of this study is to report early clinical outcomes of this eye-preserving treatment strategy in Korean patients.

II. MATERIALS AND METHODS

1. Patients

We identified 93 patients who were diagnosed of uveal malignant melanoma and treated with Ru-106 brachytherapy between 2006 and 2012 in our institution. Patients with iris and ciliary body melanoma were excluded (n=5) in this study. Patients who received radiation therapy to head and neck previously were also excluded in this study. Since Ru-106 plaque generally considered to treat tumor less than 6-7mm in height, our patients were divided into two groups according to tumor height measured by ultrasonogram; large group: tumor height ≥6 mm, small group: tumor height < 6 mm.

2. Brachytherapy

The treatment was intended to deliver 85-95 Gy to the apex, not exceeding 1000 Gy to the scleral surface. However, due to rapid radiation dose fall-off of Ru-106, 80% of the dose has already been absorbed at 5 mm from the applicator. Thus, Ru-106 plaque with 1000 Gy to the base conveys less than 100 Gy to over 7 mm from the base, an amount generally considered to be insufficient for treatment for large tumor. The patients were informed of this limitation but some patients preferred brachytherapy in an effort to preserve their eyes.

The three applicators most frequently used have diameters of 15.3, 17.9 and

20.2 mm with active diameters of 13.5, 15.8 and 18 mm, respectively (CCA, CCD, CCB). Applicators for treatment of juxtapapillary tumors (tumors located immediately adjacent to the optic nerve) have a section cutout for the optic nerve (COB, CIB).

3. Local therapy

Some patients treated with brachytherapy received additional TTT and/or local excision. The TTT procedure was performed at the time of plaque removal with an infrared diode laser using a slit-lamp delivery system. And during follow-up time, additional planned TTT procedures were performed in an out-patient setting at intervals of 3 months.

For patients with large tumor (height ≥6 mm), enucleation was generally recommend since Ru-106 brachytherapy is not suitable for large tumor. However, for patients who refused enucleation, local excision of the tumor was performed to reduce the height of apex. If the tumor was mainly located near the ciliary body, a transscleral tumor resection was performed and if the tumor had a posterior location with a basal diameter of less than 15 mm, endoresection by pars plana vitrectomy was performed.

4. Evaluation of outcomes

The primary end point is eye-preservation rate (free from enucleation). In addition, local control, overall survival and rate of distant metastasis were assessed.

Survival is calculated from the insertion of eyeplaque to any event. Patients with follow-up loss will be censored. Late toxicity will be evaluated according to Radiation Therapy Oncology Group (RTOG) scale.

Tumor response was evaluated by fundoscopy and ultrasonography, with a flat scar, or a regressed lesion not showing any signs of tumor activity representing tumor control. Local recurrence was defined as signs of tumor activity on fluorescein angiography, or documented tumor growth more than 30% of initial diameter or height. Metastases were detected by routine follow- up investigations (liver ultrasonography and blood chemistry tests) or by [18F]-fluorodeoxyglucose positron emission tomography (FDG-PET).

To assess toxicity of treatment, regular follow up for visual acuity and other ophthalmologic evaluation was done. Complications such as retinopathy, maculopathy, optic neuropathy, retinal hemorrhage and exudative retinal detachment were evaluated at each follow-up. In this study, among these findings, those needed further treatment were only defined as complications. Vital status of all patients was known from medical records. Vision was determined using WHO criteria, with low vision defined as visual acuity less than 1/3, whereas a vision <0.1 equals legal blindness.

5. Statistical analysis

The survival curves will be estimated using the Kaplan-Meier method, and comparisons between two patients group will be made with the log-rank test.

Multivariate analysis on eye preservation rate, distant metastasis and overall survival will be performed with the Cox's regression model. P values <.05 will be considered significant. Statistical analyses will be performed with SPSS version 20.0.0 (SPSS, Chicago, IL).

III. RESULTS

1. Patients and treatment characteristics

Between 2006 and 2012, 93 patients with choroidal melanoma were treated with Ru106 brachytherapy. Five patients treated with iris and ciliary body tumor were excluded, leaving 88 patients in the analysis. The median follow-up was 30 month (range 2-79 months) for patients alive.

The patients' demographics and tumor characteristics are summarized in table 1. The median age was 49 years (range 19-82). The initial visual acuity in the affected eye was ≥0.10 in 71% (n = 63) and ≥0.9 was in 16% (n = 14). Twenty five (29%) patients were diagnosed with legal blindness before treatment. The median basal tumor diameter was 11.4mm (range 2.6-17.3 mm) and median tumor height was 6.8mmm (range 1.7-13.7 mm). The number of patients with tumor height ≥6 mm (Large group) was 50 (57%) and patients in small group were 38 (43%).

Table 1. Patient characteristics

Characteristic (n = 88)		**N (%)**
Sex	Male	44 (50)
	Female	44 (50)
Age (years)	≥50	44 (50)
	<50	44 (50)
Affected eye	Right	39 (44)

Characteristic (n = 88)		N (%)
	Lt	49 (56)
Initial visual acuity	<0.1 (Legal blindness)	25 (29)
	0.1-0.8	49 (56)
	≥0.9	14 (16)
Pigmentation	Melanotic	75 (85)
	Amelanotic	13 (15)
Proximity to optic nerve	Central/Juxtapapillary	32 (36)
	Peripheral	56 (64)
Basal diameter	Median 11.4 mm (range, 2.6-17.3)	
Tumor height	Median 6.8 mm (range, 1.7-13.7)	
COMS stage	Small	4 (5)
	Medium	73 (82)
	Large	11 (13)

Abbreviations: COMS= Collaborative Ocular Melanoma Study

The treatment characteristics are described in table 2. Combined treatment was used in the treatment of 75% (n = 66) of the patients. In large group (tumor height ≥6 mm), 96% (n = 48) of patients was received combined local therapy (TTT aloe: 50%; local excision 46%). In small group (tumor height <6 mm), 45% (n = 17) of patients was treated with combined treatment, relatively. Radiation dose was prescribed to the apex of the tumor for 53% of patients and to the 2 mm point from the outer surface of the sclera for 47% of patients after local excision.

Table 2. Characteristics of brachytherapy

Characteristics		**N (%)**	
Type of eyeplaque	COB	45 (51)	
	CCA	18 (21)	
	CCB	18 (21)	
	CIB	7 (8)	
Combined treatment	No	23 (26)	
	Yes	65 (74)	
	TTT alone	39 (44)	
	Large group		25 (50)
	Small group		14 (37)
	Tumor excision	26 (30)	
	Large group		23 (46)
	Small group		3 (8)
Prescription point	Apex	48 (55)	
	2 mm point from the sclera	23 (26)	
	Others	17 (19)	
Dose to sclera	<500 Gy	42 (48)	
	500-1000 Gy	39 (44)	
	> 1000 Gy	7 (8)	
Time to removal	85 (12-238) hours		

Abbreviations: TTT= transpupillary thermotherapy

2. Local control, distant metastasis and overall survival

Local progression was diagnosed in 13 patients. The actuarial 3-year local control rate was 80% (Fig. 1). Three-year local control rate was significantly higher in small group than those in large group (94% vs. 70%, respectively; $p = 0.047$). Salvage treatments for local recurrence consisted of enucleation (n = 12) and additional TTT (n = 1).

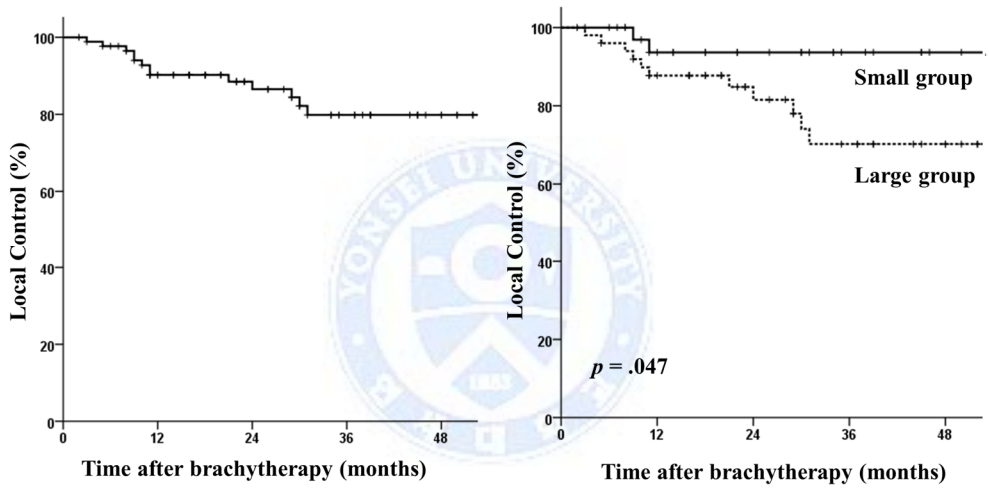

Fig. 1. Local control for all patients and for two groups

Distant metastases were diagnosed in 12 patients and total of 1 patient died. Three-year metastasis free survival was 84% and overall survival was 90% for all patients. The distant metastasis free survival (DMFS) and overall survival (OS) was also significantly higher in patients in small group (3yr DMFS: 97% vs. 76%, p =

0.031; 3yr OS: 97% vs. 72%, $p = 0.036$). (Fig. 2)

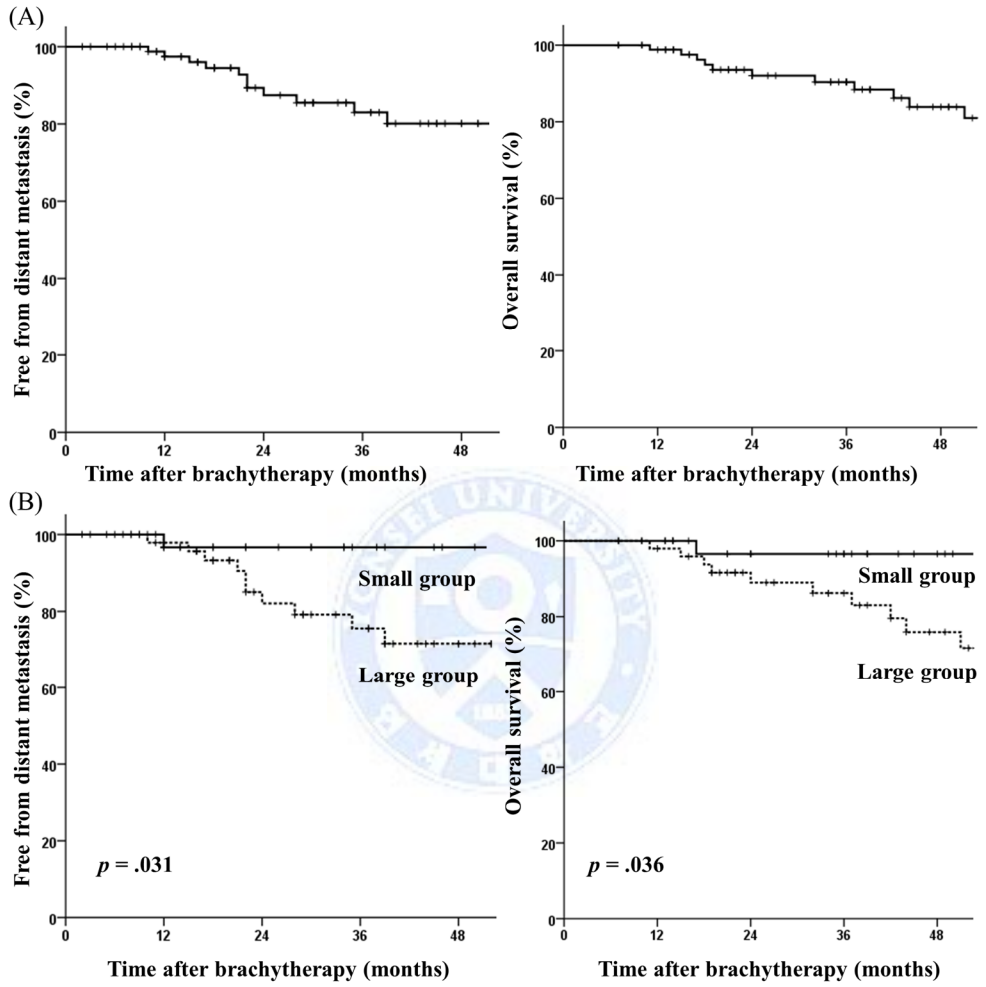

Fig. 2. Distant metastasis free survival and overall survival for all patients (A) and for two groups (B)

3. Eye preservation

Among the 88 patients, 13 patients eventually underwent enucleation, resulting in a 3-year actuarial eye-preservation rate of 80%: 12 patients for local recurrence and 1 patient for complication. In small group, only 2 patients underwent enucleation due to tumor progression showing 3-year eye-preservation rate of 94%. Eye-preservation rate is significantly higher in this group when compared with those in large group (3yr 94% vs. 70%, $p = 0.050$). (Fig. 3)

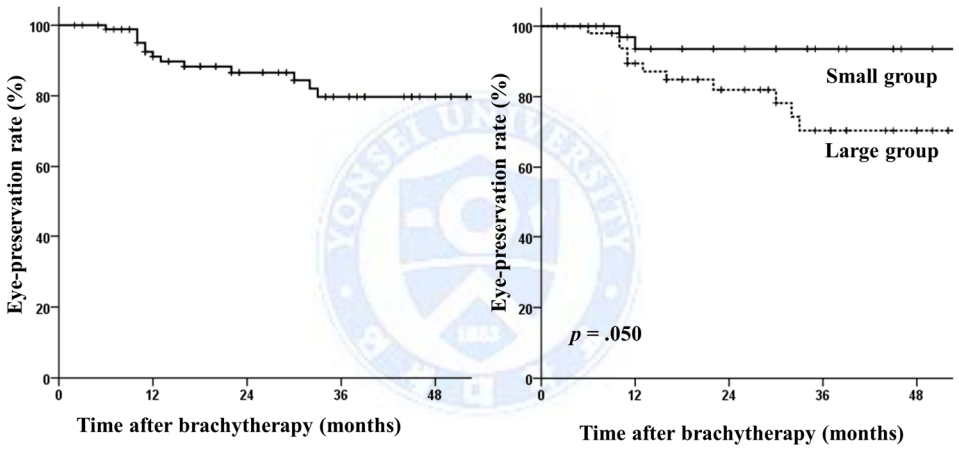

Fig. 3. Eye preservation rate for all patients and two groups

4. Toxicities

The total amount of complications which requiring further treatment was only 7% (n = 6) after treatment. The types and number of complications and the interval from brachytherapy is described in Table 3. One patient in large group wanted

to undergo enucleation for phthisis 10 months after brachytherapy. This patient had large tumor with height of 9 mm and received TTT after brachytherapy. Dose to sclera of this patient was exceeded 1000 Gy.

Among 63 patients with a pre-treatment visual acuity greater than 0.10, 39 patients (62%) had a deterioration of visual acuity in the treated eye to <0.10, thus to legal blindness. Fifty percent of tumor was close to macula or optic disc among these patients. Actuarial rate of preserved vision greater than 0.10 was 38% (n = 24).

Table 3. Radiation related toxicities

Pts	Age	Sex	TBD (mm)	TH (mm)	Location	Radiation dose			Toxicity	Int	VA		En	Int
						Sclera	Lens	Optic disc			Initial	Last		
1	25	F	10.87	9.89	Peripheral	834	0	41.7	NVG	15	0.3	0.05	Yes	16
2	49	F	10	2.4	Central	199.4	0	33.6	Retinopathy	20	0.01	0.1	No	.
3	55	M	13.91	12.67	Peripheral	197.9	11.53	0	Uveitis	10	0.5	NA	No	.
4	66	M	10.9	8.37	Peripheral	132.8	0	13	NVG	7	0.05	LP (-)	No	.
5	70	F	11.01	6.68	Central	978.2	0.003	181.7	Phthisis	12	0.6	LP (-)	Yes	10
6	71	F	9.94	4.87	Peripheral	513.9	0	36	NVG	14	0.7	LP (-)	Yes	13

Abbreviations: Pts= Patients, TBD= Tumor basal diameter, TH= Tumor height, NVG= Neovascular glaucoma, Int= Interval, VA= Visual acuity, LP= Light perception, Enu= Enucleation

5. Prognostic factors

The following potential prognostic variables were examined in the multivariate analysis: Age (<50 vs. ≥50 years), initial visual acuity, tumor height (<6 mm vs. ≥6 mm), basal diameter. Cox regression analysis of prognostic factors for eye-preservation, distant metastasis and overall survival were used (Table 4). Significant prognostic factor for eye-preservation was tumor height ≥6 mm (Hazard ratio 9.560, 95% CI 1.235-73.984, $p = 0.031$). Tumor height was not significantly associated with distant metastasis and overall survival ($p = 0.135$ and $p = 0.157$, respectively). Other characteristics including age, initial visual acuity, basal diameter and location of tumor did not affect the patients' prognosis.

Table 4. Prognostic factors by multivariate analysis

Characteristics	Eye preservation			Distant metastasis			OS		
	HR	95% CI	*p*-value	HR	95% CI	*p*-value	HR	95% CI	*p*-value
Age			0.229			0.515			0.144
<50 years	1			1			1		
≥50 years	2.214	0.606-8.091		1.489	0.410-5.415		3.166	0.674-14.872	
Visual acuity			0.359			0.442			0.749
<0.1	1			1			1		
0.1-0.5	2.245	0.561-8.990		0.447	0.128-2.448		1.315	0.245-7.057	
0.6-0.8	0.484	0.047-4.995		0.126	0.110-1.819		0.972	0.240-3.940	
≥0.9	0.769	0.070-8.422		0.358	1.0.7-3.496		0.659	0.120-3.157	
Tumor height			0.031			0.135			0.157
<6 mm	1			1			1		
≥6 mm	9.560	1.235-73.984		5.828	0.576-58.962		6.122	0.497-75.399	
Basal diameter			0.375			0.89			0.288
<8 mm	1			1			1		
8-14.99 mm	1.166	0.922-1.473		1.078	0.864-1.345		1.243	0.893-1.564	
≥15 mm	1.187	0.812-1.572		1.162	0.901-1.452		1.312	0.651-2.021	
Tumor location			0.976			0.62			0.926
Peripheral	1			1			1		
Juxtapapillary	1.021	0.267-3.901		0.717	0.192-2.699		0.939	0.248-3.560	
Local Treatment			0.103			0.92			0.856
No	1			1			1		
Yes	0.249	0.047-1.322		0.887	0.087-9.096		0.806	0.079-8.266	

IV. DISCUSSION

In this analysis, outcomes of Ru-106 brachytherapy with or without additional local treatment were evaluated in 88 patients with choroidal melanoma of variable size. We found favorable local tumor control and eye-preservation rates showing 3-year local control rate of 80% and 3-year eye-preservation rate of 79 % regardless of tumor size. Patients in small group (height <6 mm) show excellent local control rate and eye-preservation rate (3-year 94% and 94%, respectively) and these results are comparable to those reported by other groups for small or medium sized tumors.[10]

Although enucleation is the most common primary management of large (height ≥6 mm) choroidal melanomas, several studies have shown I-125 brachytherapy to be a possible alternative treatment with regard to survival and local tumor control. However, a few studies have reported using beta-radiation emitting Ru-106 to treat large choroidal melanoma. The problem with Ru-106 could be its limited depth of penetration, which might not reach the apex of thick tumors.[11] When compared with I-125, Ru-106 has a threefold faster radiation dose fall-off. The effective amount of radiation of 80-100 Gy reaches less than 7 mm when Ru-106 eyeplaque with 1000 Gy to the outer surface of sclera is used. Thus, thicker tumor might receive insufficient radiation dose to its apex. On the other hand, for the same radiation dose delivered to the apex, the base irradiated by Ru-106 receives up to three times more radiation than I-125. This might cause extensive damage to the

sclera. On the basis of these findings, in present study, most patients in large group (96%) received additional local treatment with TTT or tumor excision or both.

Tumor necrosis by TTT is induced to depth of 3mm from apex.[12] The effectiveness of combined use of Ru-106 brachytherapy and TTT has been demonstrated in several studies, as with TTT the apex of the tumor is treated up to 3mm, while with brachytherapy the high dose is given to the tumor base.[8,13,14] In addition, among patients in large group (height ≥6 mm), local excision of the tumor was performed in 46% of patients. In this case, prescription point was determined at 2mm from the outer surface of sclera. Augsburger *et al* previously reported choroidal melanoma with extrascleral extension treated by surgical excision of the extrascleral nodule followed immediately by plaque radiotherapy of the intraocular tumor.[15] They showed the efficacy of combination of local excision and brachytherapy in treatment for choroidal melanoma which was not suitable for brachytherapy alone. Adding these local treatments to Ru-106 brachytherapy could increase local control of patients with tumor prominences exceeding 6 mm, which is generally regarded as the maximum height suitable for Ru-106 brachytherapy. Furthermore, it is expected to reduce radiation dose to scleral surface so the risk of radiation induced toxicities would be decreased.

Choroidal melanoma is relatively resistant to radiation and the brachytherapy dose needed to eradicate this tumor is associated with a considerable risk of radiation damage to ocular structures. In our analysis, the actuarial rate of radiation related side

effects which require further treatment was 7%. One of these patients underwent enucleation for persistent phthisis after brachytherapy. This patient received high dose of radiation to sclera exceeding 1000 Gy with high dose rate (dose rate to sclera: 502.9 cGy/hr). Sixty two percent of patients who had effective visual function at initial diagnosis eventually experienced complete loss of visual acuity at their last follow-up, which is comparable to other large series.[16,17] Half of these patients had tumor close to macula or optic disc. Radiation induces acute transudative and slowly progressive late occlusive vasculopathy with neovascularization and retinal edema, resulting in deterioration of visual acuity in the affected eye which is ongoing over the years after treatment. Increased dose and dose rate to macula and optic disc were associated poorer visual outcome.[18] Recent data suggests that treatment of radiation retinopathy with intravascular anti-vascular endothelial growth factor such as bevacizumab may decrease neovasculization and retinal edema resulting in improvement of visual acuity.[19]

Nevertheless, according to our data, the combined use of brachytherapy and other local treatments can make it possible to treat choroidal melanoma with a thickness higher than 6 mm with Ru-106 plaque radiotherapy and improve local and eye-preserving outcomes. Eighty percent of patients initially treated with brachytherapy could be salvaged from enucleation. The 3-year eye-preservation rate is 94% in small group and 70% in large group, respectively. This result is comparable with 70-90.3% of eye preservation reported after I-125 brachytherapy for thick

melanomas and with 82-88% reported after Ru-106 brachytherapy for any size tumor.

We investigated the distant metastasis and the survival rate of choroidal melanoma patients and the estimated 3-year DMFS and OS were 84% and 90%, respectively. This result is in accordance with previous studies on Ru-106 brachytherapy reporting the 5-year OS at 80-84%.[17,20-22] Patients in large group showed poorer outcome than in small group (3yr DMFS: 97% vs. 76%, $p = 0.031$; 3yr OS: 97% vs. 72%, $p = 0.036$). This result demonstrates the deleterious effect of poor local control on distant metastasis and overall survival in patients with large tumor despite the additional local treatment.

In interpreting our data, the limitations of retrospective analysis including patients and treatment selection must be considered. The absolute indication for brachytherapy with additional local treatment is unclear, but the use of this treatment seems to reliably be recommended for improvement local control. Another limitation lay on the difficulty in evaluating toxicities because the changes in the retina were due to radiation alone or tumor growth as well and these changes may have existed at initial diagnosis. Toxicity analysis includes only the patients requiring further treatment in this study, so incidence of toxicities cannot be directly applied to all patients with choroidal melanoma treated with Ru-106 brachytherapy. Since the cohort is relatively small, there were limitations in conducting a complete statistical analysis. It is necessary to verify the prognostic factors identified in our data. Nevertheless, the strength of our study is that our patients received relatively

homologous treatment in consideration of tumor size and is performed in a single institution.

V. CONCLUSIONS

We have confirmed the efficacy of Ru-106 brachytherapy for eye preserving treatment for patients with choroidal melanoma with favorable local control and eye-preservation. When combined with other local treatment, Ru-106 brachytherapy could be one of treatment options for large tumor with thickness ≥6 mm.

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ABSTRACT (IN KOREAN)

맥락막 흑색종 환자에서 루테늄-106 브라키테라피를 이용한 안구보존적 치료의 임상적 결과

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조 연 아

목적: 본 기관에서는 2006년 이후로 다른 국소 치료와 함께 혹은 단독으로 루테늄-106 브라키테라피로 맥락막 흑색종 환자를 치료해 왔다. 본 연구의 목적은 다양한 크기의 맥락막 흑색종에서 이러한 안구 보존의 치료 전략의 초기 임상적 결과를 보고자 함이다.

대상 및 방법: 2006년 10월부터 2012년 9월까지 총 93명의 환자들이 포도막 흑색종으로 치료롤 받았고 그 중 홍체 및 모양체의 종양으로 치료 받은 사람은 제외하여 총 88명의 환자들을 분석하였다. 본 기관에서는 다양한 크기의 환자들을 루테늄-106 브라키테라피로 치료를 했고, 6mm 이상의 높이의 종양은 국소 절제나 동공 통과 열치료 (Transpupillary thermotherapy, TTT)를

함께 시행했다. 일반적으로 종양의 정점에 85 Gy를 처방 하였고, 국소 절제를 받은 환자들에게는 공막 표면으로부터 2mm 되는 지점에 100 Gy를 처방하였다.

결과: 대상 환자의 중앙추적조사기간은 30 개월이었다. 중앙 나이는 50세 (19-82세) 였고, 종양의 직경의 중앙 값은 11.4 mm (2.96-17.28 mm), 높이의 중앙 값은 6.79 mm (1.73-13.66 mm)였다. 3년 국소 제어율은 80% 였다. 원격 전이는 12명의 환자에서 진단되었고 그 중 11명의 환자가 사망하였다. 3년 원격 전이율은 84%, 생존율은 90.3% 였다. 88명의 환자 중에서 12명의 환자들이 결국 안구 적출을 시행 받았으며, 11명은 국소 재발로 인해, 한명은 방사선 치료로 인한 독성 때문이었다. 안구 보존률에 영향을 미치는 유의한 예후 인자로는 종양의 높이 p = 0.042 였다. 종양의 높이가 6mm 이상인 환자는 50명(57%)이었으며, 그 중 94% (47명)의 환자가 국소 치료를 함께 시행 받았다. 종양의 높이가 6mm 미만인 환자의 3년 안구 보존률은 94% 였고, 6 mm 이상이었던 환자는 70% 였다. 6mm 미만의 환자 중 단 한명만이 원격 전이를 보였고 결국 질병으로 인해 사망하였다.

결론: 루테늄-106 브라키테라피를 이용한 다양한 크기의 맥락막 흑색종의 치료는 비교적 좋은 결과를 보였다. 추가적인 국소치료로

비교적 큰 크기의 종양에서도 안구 보존률을 높일 수 있다.

핵심어: 맥락막 흑색종, 브라키테라피, 아이플라크, 루테늄-106, 안구 적출