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Treatment of Orbital Lesions using CyberKnife Stereotactic Radiosurgery

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Introduction

The purpose of the research done was to evaluate the use of CyberKnife Stereotactic Radiosurgery (SRS) for treating orbital lesions. Efficacy and tolerability of such treatment was analyzed with data drawn from multiple sources, regarding dose and fractionation, quality of life following treatment(s) and prognosis. CyberKnife SRS is the newest, most advanced model of radiation delivery systems, featuring a robotic arm capable of manipulating the linear accelerator into thousands of unique angles. The addition of new angles allows for a more precise concentration of radiation delivered to the lesions. In the case of optic lesions, it is crucial to minimize dose to adjacent structures such as optic nerve, lens and fovea. CyberKnife SRS is superior for treatment in small anatomical locations due to steep dose gradients and target localization system, allowing maximum sparing of organs at risk. While CyberKnife SRS is rapidly becoming the gold standard for orbital lesions, there is still a likelihood that other treatments may be required as an adjunct therapy for treatment purposes. However, current research identifies the high success rate of CyberKnife SRS but acknowledges the need for further research in dosage and fractionation.

CyberKnife Stereotactic Radiosurgery is:

- the newest type of stereotactic radiosurgery; consisting of a 6-MV linear accelerator fixed on an image-guided, computer-operated frameless robotic arm
- 30 to 90 minutes per treatment
- used to treat lungs, pancreas, brain, head and neck, spine and prostate cancers

(Long et al., 2019, p. 451)

Fig. 1

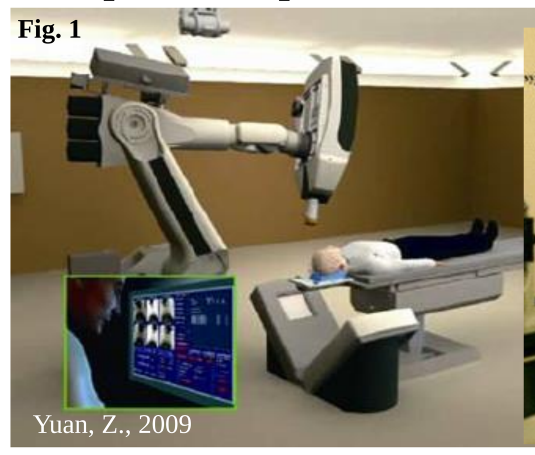
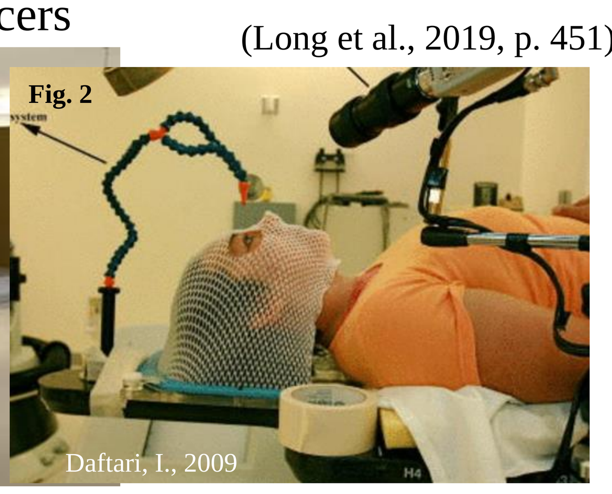


Fig. 2



CyberKnife room setup and patient in immobilization mask for treatment

- non-invasive and usually done in less than 5 fractions (days) at a high dose, with a more minimal dose to surrounding tissue than conventional radiotherapy
- proven superior by its specialized target spatial localization system and steep dose gradient which allow for maximum sparing of organs at risk
- image-guided which allows the robotic arm to track patient movement within 0.5-10.0 mm and 1-3 degrees and remain aligned to the target area

(Riva et al., 2019, p. 62)

Orbital Lesions

- Damage or abnormal change in tissue in or around the orbit
- Cancer that has metastasized to the eye is more common than a primary orbital cancer (American Cancer Society, n.d.,)
- Melanoma is the most prevalent eye cancer, with uveal melanoma being the most frequent primary intraocular tumor

(Klingenstein et al., 2016, p. 1005)

Types of Orbital Lesions

- Intraocular- within the orbit
- Periocular-surrounding the orbit (muscles & adnexa)
- Pseudotumor- swelling behind the orbit
- Primary or Metastasized

Etiology

- Age, thyroid disorders, systemic lupus erythematous, rheumatoid arthritis, fibro-inflammatory disorders, sarcoidosis, and granulomatosis with polyangiitis
- Mean age: 65 +/- 10 (Yaprak et al., 2018, p.198)
- Orbital metastases could usually be associated with a poor systemic prognosis (Riva et al., 2019, p. 64)
- Uveal melanoma is rare, but the most common cancer spread to the eye

  Usually developed in the choroid, which has a similar function to skin cells

(American Cancer Society, n.d.,)

Signs/Symptoms

- Blurred or decreased vision
- Limited ocular motility
- Diplopia (double vision)
- Swelling
- Proptosis (protrusion)
- Epiphora (watering)
- Pain
- Redness

(Yaprak et al., 2018, p.198)

Fig. 3

Orbital cavernous hemangioma before & after

Treatment Options

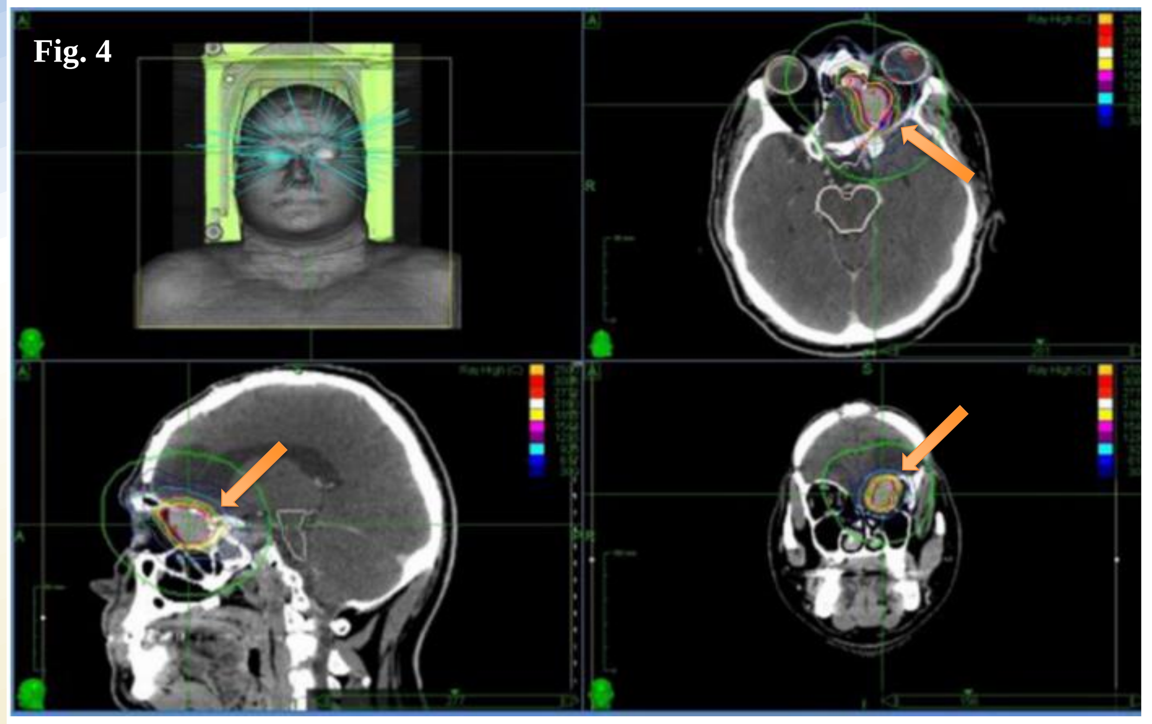
- Radiation Therapy treatment- CyberKnife, GammaKnife, IMRT, Proton therapy, Brachytherapy
- Enucleation or surgical resection (Klingenstein et al., 2016, p. 1005)
- Systemic treatments- immunotherapy, hormonal therapy, chemotherapy (Riva et al., 2019, p. 65)

Treatment Process

- Retrotubular anesthesia is administered, achieving akinesis for 2.5-3 hours
- T2- and contrast-enhanced T1-weighted MRI is acquired (see Fig. 4)
- The doctor, dosimetrist and physicist spend 30-40 minutes collaborating
- The visible tumor is contoured as the target volume
- Inverse treatment planning is done to create a steep fall in dose outside the tumor volume
- The patient is positioned on the table with an immobilization mask
- The linear accelerator delivers 100-150 beams at differing angles
- MR images are taken at each new angle to account for position of tumor due to movement
- The entire process is completed within 2.5 hours

(Klingenstein et al., 2016, p. 1007)

Fig. 4



Treatment plan using CT images, showing tumor volume and beam angles

(Desideri et al., 2019, p. 2)

Dose & Fractionation

- Treatments are non-isocentric
- Dose ranges on the size of the tumor and facility preference
- No standard recommendation for dose and fractionation exists (see examples below)
  - 17-22 Gy in one fraction with 12/39 patient experiencing reoccurrence (Desideri et al., 2019, p. 4)
  - 15 Gy over 3 fractions with partial regression after 12 months
  - 15 Gy over 3 fractions with complete recovery (Klingenstein et al., 2016, p. 1007)
  - 19 patients treated with 24-35 Gy over 1-5 fractions with 75% overall response rate
  - 13 patients treated with 13-22 Gy over 3-5 fractions with 100% overall response rate

(Yaprak et al., 2018, p.199)

Considerations

Benefits

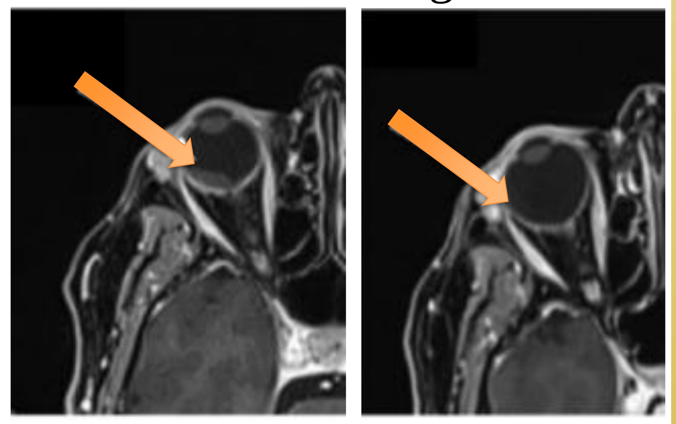
- Reduced tumor volume (size), offering immediate symptom relief
- Delays the need for surgery or enucleation
- Ideal for palliative treatment (Desideri et al., 2019, p.2-5)
- Short treatment length allows focus on other procedures (Riva et al., 2019, p. 65)

Risks

- Orbital irradiation may lead to a wide spectrum of acute and late toxicities such as: permanent blindness, conjunctivitis, panophthalmitis, dry eye syndrome, cataract, keratopathy, retinopathy, neovascularization of the iris, and optic neuropathy (Riva et al., 2019, p. 65)
- Optic pathways and orbital adnexa are radiosensitive periocular structures that are prone to late toxicity (Desideri et al., 2019, p.2)
- In the long term, functional and cosmetic disturbances may reduce quality of life

Prognosis/Outcome

- Primary lesion of the orbit 5-year survival rate: 85%
- Metastasized 5-year survival rate: 71% (American Cancer Society, n.d.,)
- Most reported cases presented a monophasic disease course, yet there was some reoccurrence
- Reoccurrence was more common among those below mean age, bilateral disease, and/or partial initial steroid response (Sasaki et al., 2021, p. 199)



Before & after treatment with CyberKnife (Riva et al., 2019, p. 65)

Conclusion

Most research points toward CyberKnife SRS as a safe, efficient and effective treatment method for orbital lesions. Currently, no recommendation exists about correct doses and fractionations for this treatment. These factors should be carefully planned according to proximity of critical structures, histology, and target lesion volume. Current research suggests CyberKnife is a safe and effective course of treatment. Further research must be conducted to fully understand the most efficient planning of treatment for orbital lesions using CyberKnife SRS.