Master's Thesis Engineering Technology 2021-2022

A more detailed analysis of the properties of the OrthoChrome OC-1 radiochromic film

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Introduction

Dosimetry is an **essential** part of radiotherapy (see figure 1). The quality of dosimetry directly **influences the treatment results**. **Film dosimetry** is often used in practice due to its **accuracy, reliability** and **relative inexpensiveness** [2].

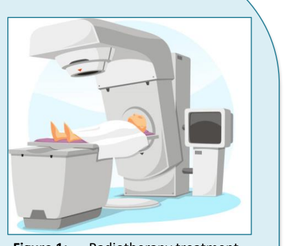

Figure 1: Radiotherapy treatment example [1]

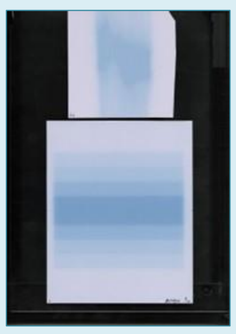

Figure 2: example of field calibration (bottom film) and treatment plan (top film) using OC-1

The **OrthoChrome OC-1** is a **new radiochromic film** for film dosimetry that promises better results than the competition due to a **reduced lateral artefact** because of the **chemical composition** of the film and thanks to its **new field calibration technique** (see figure 2). However, the **properties** of this film are still **unknown** because of its novelty.

Objectives

The **objectives** of the study were to determine the following properties of the OC-1 film:

- the **performance** using **strip** (see figure 3) and **field calibration** (see figure 2);
- **performance** of field calibration using a **flattening filter free (FFF) beam**;
- **performance** of field calibration using **different scanner positionings**;
- **performance** of field calibration using different **prefilter** and **lateral discretization settings**;
- the **energy dependence** of the film;
- the **development after irradiation**;
- **sensitivity** to **UV light** and **multiple scanning**.

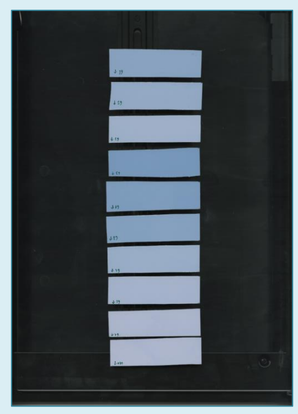

Figure 3: Example of strip calibration using OC-1

Methods and materials

Firstly, the **performance** of the OC-1's **field calibration** was tested in **comparison** with **strip calibration** by performing a **gamma analysis** on a **prostate treatment plan**. The effect of **different energies** and **scanner positionings** was tested by performing a **gamma analysis** on a **simple field** plan. Both experiments used the **setup in figure 4** for calibration and irradiation. **Matching settings** were tested by **varying** the **prefilters** and **lateral discretization settings**.

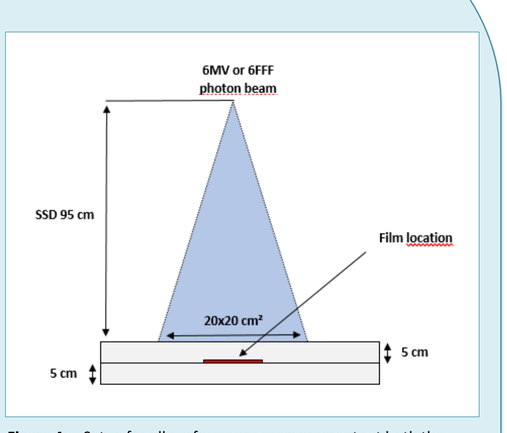

Figure 4: Setup for all performance measurements at both the Jessa Hospital and the Maastro Hospital

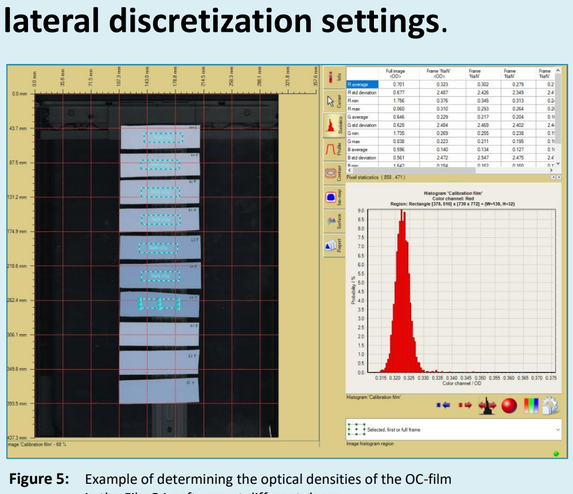

Figure 5: Example of determining the optical densities of the OC-film in the FilmQA software at different doses.

Energy dependence was determined by **measuring** the **optical density** of **different doses** at **each energy** (see figure 5). **Optical density** was also **determined** for **10 days after irradiation** to **quantify further development** of the film Finally, **sensitivity to sunlight** and **multiple scanning** was tested by **exposing** pieces of film for **one week** and **scanning** them **30 times.**

Results and conclusion

The **field calibration** of the OrthoChrome OC-1 film **performed significantly worse** than the **strip calibration** with both EBT3 and OC-1 itself (see figure 6). The use of an **FFF beam** does **not affect** the **performance** of the **field calibration**. The **scan positioning** does **not** seem to have **an effect** either but the **use of the prefilte**r has a **significant negative impact** on the passing rate.

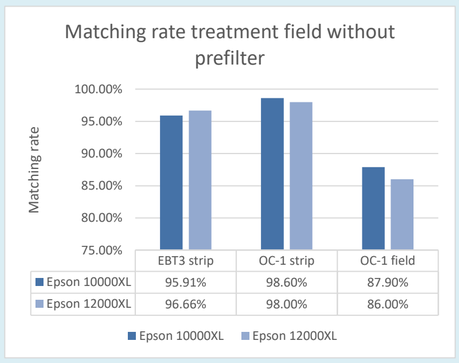

Figure 6: Matching rates of treatment plan using different EBT and OC-1 calibrations

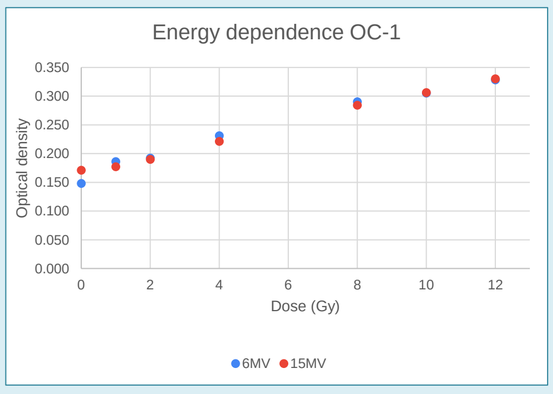

Figure 7: Optical density of OC-1 in function of dose using 6 and 15 MV energies

The **OC-1** shows only small deviations in optical density between 6 and 15MV (see figure 7) and can be considered **energy independent**. The **development** of the film **after irradiation** is **larger** than that of **EBT3** but is **possibly caused** by development due to **ambient light**.

Finally, it was found that the film is **highly sensitive** to **sunlight** (see figure 8) but **can be scanned up to 30 times** without darkening of the film.

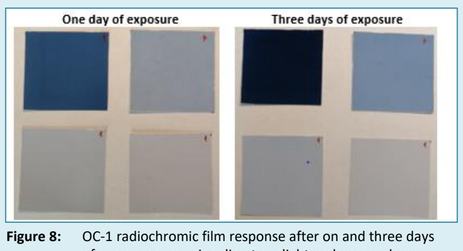

Figure 8: OC-1 radiochromic film response after on and three days of sun exposure using direct sunlight and no envelope (top left), direct sunlight and envelope (top right), indirect sunlight and envelope (bottom left), no sunlight and envelope (bottom right)

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[1] iStock, 'Thérapie de radio - Illustration libre de droits', *iStock*, 2016. https://www.istockphoto.com/fr/vectoriel/th%C3%A9rapie-de-radio-gm537308754-95181693 (accessed May 07, 2022).

[2] S. Devic, 'Radiochromic film dosimetry: past, present, and future', *Phys. Medica PM Int. J. Devoted Appl. Phys. Med. Biol. Off. J. Ital. Assoc. Biomed. Phys. AIFB*, vol. 27, no. 3, pp. 122–134, Jul. 2011, doi: 10.1016/j.ejmp.2010.10.001.

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