A manual Multileaf Collimator for use in Cobalt-60 teletherapy

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BACKGROUND

Multileaf Collimators (MLC) for conforming radiation fields to a target shape have been in use for more than 20 years. [1,2] Due to the dominance of linear accelerators (LINAC) in radiation therapy in the western world over Cobalt-60 (Co-60) teletherapy devices these MLC have always been developed for use in a LINAC or dedicated machines.[3,4,5] Despite the undisputed benefits and predominance of linear accelerators in radiation therapy, currently a total of 2344 Co-60 teletherapy machines [6] are still in use worldwide mostly due to their relatively lower costs, simplicity of design and ease of operation. [3] Special infrastructural requirement such as limited access to electric power and servicing personnel remain present in many institutions in the non-western world. The quest for the application of modern technological advances in Co-60 radiotherapy that are standard in Linac radiotherapy - as, for instance, a MLC - has been mentioned frequently. [3,4,7,8]. Recent studies of a motorized MLC have been reported [9,10] but not been commercially available to this date.

This report presents the novel manual MLC for conforming the beam of a Co-60 gantry based teletherapy device to irregular field shapes.*

MATERIAL AND METHODS:

For the special requirements present in many low-infrastructure environments, a manual MLC was developed to be used with a Co-60 teletherapy machine. The main requirements for this collimator were defined to be a low costs, highly reliable, low maintenance, independent of electric power and versatile in its applicability. Therefore it should serve as a detachable accessory to allow comparable treatments as with Linacs only with manual means.

*The outer dimensions are approximately 600x300x155 mm3 (l,w,h) with a total weight of approximately 40 kg. A top plate which is fitted to the accessory tray is firmly attached to the collimator to allow for removability. The maximum field size is 20*30cm2 in the isocentre. Overtravel is not implemented for the prototype.*

A novel drive mechanism for the individual leafs has been implemented by using a passive closed-loop, semi-automatically pneumatic system. This is in contrast to electrical step motors or active pneumatic system as in commercially available binary MLC. A total pressure

* Prototype version of CobRaLeaf® (Precisis AG, Heidelberg, Germany)

of 10 bar is applied to the backside of the leafs. The sealed system with a constant air mass allows the semi-automatic movement of the leafs. A crossing bar enables the user to perform a single movement to return all leafs simultaneously to the outmost position. It touches the leafs from the inside and can be operated manually with a crank handle.

A unique clamping system with a lever to the outside applies lateral force to the leafs during the irradiation in order to eliminate interleaf leakage.

The MLC consists of thirty leaf pairs, arranged in a fan-shaped setting to align with the divergence of the beam. The leaf height for the prototype is 98mm of Brass (CuZn39Pb3) which corresponds to a theoretical transmission of 1.46 % for 1.332MeV [11]. The mass of each leaf is approximately 0.55 kg. The upper leaf edge has a width of 5.9 mm and conforms to the beams divergence by incorporating an angle of 0.7° per leaf. The leaf width in the isocentre is 10 mm, if attached to 80 cm SAD machine. The partly rounded leaf ends further reduce the penumbra in the direction of the movement of the leafs (longitudinal) and provide a relatively constant relationship between light field and irradiated field.

The workflow for a multiple field treatment is as follows: At first, the leaf pairs are opened against the force of the air pressure by turning the crank handle. The field shaped PMMA templates, which are attached on a indicator plate for centering, are inserted. After releasing the crank handle the air pressure moves the leafs to the intended target position. The field templates can either be taken from a standard set or by individual manufacturing.

The Co-60 source used in this experiment has a diameter of 15mm on a 80 cm SAD with an activity of the date of measurement of 59.4 TBq. Measurements were performed in 10cm depth and pre-collimation to the collimators maximum dimensions. Ion Chamber (IC) measurements and film dosimetry was performed to evaluate the collimators penumbra for various leaf end shapes and leakage properties.

RESULTS:

A preliminary trial with a preceding model showed first results of the functionality and dosimetric properties.

A survey among 16 users showed that the maximum field size of 20x30cm2 should account for approximately 80%-90% of the irradiated cases with a Co-60 machine.

Penumbra (defined as 80%/20% region in depth of 10cm) for large fields (20 x 12 cm2) in direction of leaf movement was 8mm and 12mm for shaped and straight leaf ends, respectively. The transversal penumbra was approximately 9 mm. Penumbra for the field of 10 x 10 cm2 showed a longitudinal penumbra of 6 mm and 7 mm for shaped and straight leaf ends, respectively. The transversal penumbra was 6 mm for this field.

Irradiating a fully closed field with shaped leaf ends showed a peak dose of three times the transmission dose.

No interleaf leakage was detectable.

DISCUSSION:

The MLC presented in this report proves to be able to conform irregular fields in a Co-60 gantry-based teletherapy device to any given isocentric shape within the given constraints. Dosimetric results prove to be consistent with expectations and published properties of Co-

60 sources. The lack of overtravel functionality and limited clearance can lead to restrictions in patient treatment that is to be improved in following prototypes. A good compromise between leaf-end design and maximum allowable central beam transmission has to be found and combined with appropriate pre-collimation of the field. An optimized leaf end shape will solve the problem of an increased central beam peak dose for closed leafs.

Apart from this, the novel design allows the use in a clinical workflow despite its independence from electronic drives. It is therefore expected to be well suited for the special requirements in low-infrastructure environments as a removable add-on to existing Co-60 machines. Further measurements with improved design are planned for the near future.

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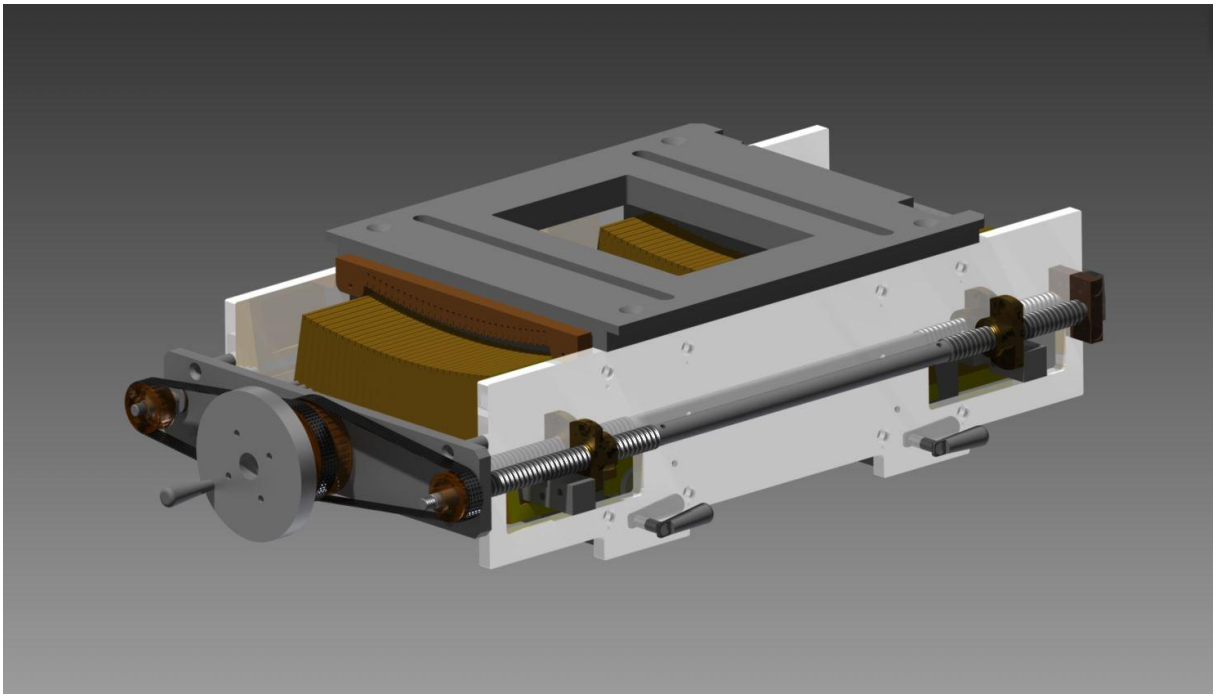
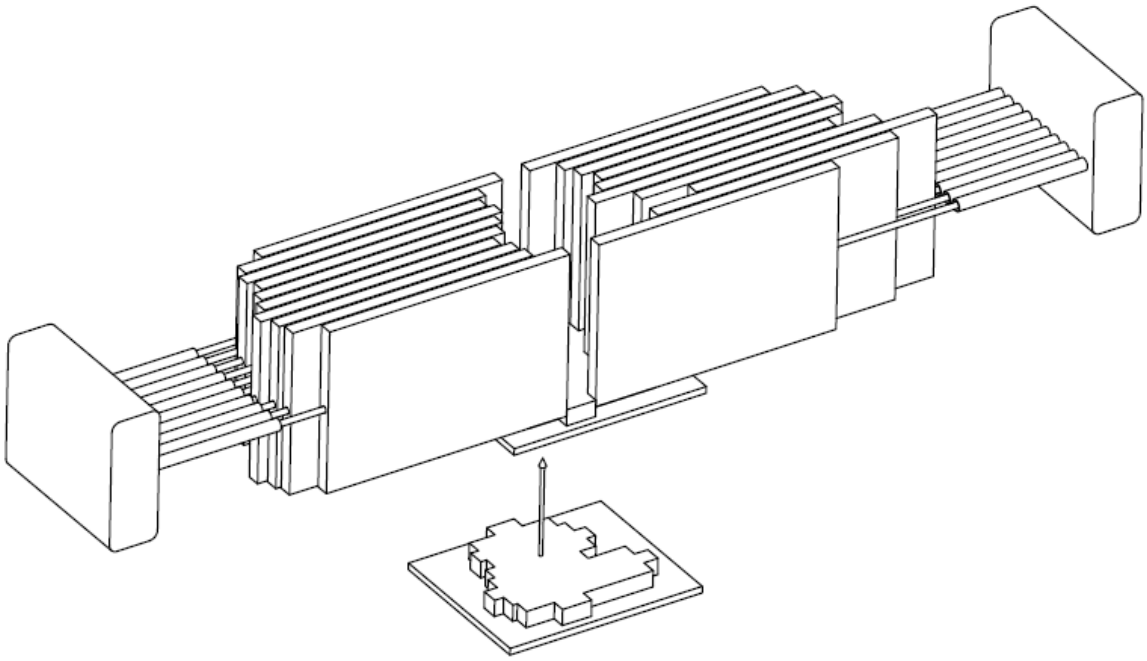


Img 1: Drawing of the MLC without the pneumatic drive mechanism and the mounting plate

Img 2: IC Dosimetric measurement setup with the preliminary model.



Img 3: Concept of leaf drive with closed-loop pneumatic volume and stanchion and the insertion of an irregular field shape template for conformal treatment.