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A prospective study to assess the performance of the improved Boron Neutron Capture Therapy Facility in Argentina

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HIGHLIGHTS

- Several planned modifications were implemented at the RA-6 reactor in Argentina.
- Modifications lead to significant benefits for future clinical BNCT treatments.
- New capabilities have been implemented in NCTPlan treatment planning system.
- Dosimetric reevaluation of clinical cases was performed in the new facility.
- Optimized plans that considered feasible patient set ups were assessed.

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ABSTRACT

From 2008 to 2011, several planned modifications were implemented at the RA-6 reactor in Argentina, leading to significant benefits for future BNCT treatments. New capabilities have been implemented in NCTPlan treatment planning system. To assess the performance of the new BNCT facility, a dosimetric reevaluation of previous clinical cases was performed, taking into account the modifications carried out in the new facility and compared the results of the original treatment plans with optimized plans that are considered as feasible patient setups.

1. Introduction

The first Boron Neutron Capture Therapy (BNCT) clinical facility in Argentina, named the "B1 beam", was developed in the RA-6 open-pool reactor located in the city of Bariloche (Rio Negro Province, Argentina) (Blaumann et al., 2004). The B1 beam exit port was circular, 15 cm in diameter opening on the wall, with a particular mixed spectrum of thermal and epithermal energies, referred to as a "hyperthermal" beam. In 2001, when the BNCT facility was built, the RA-6 reactor was working with 90% enriched U-235 fuel elements, at a 500 kW of nominal power. For 4 years (2003–2007), patients with melanoma in extremities were treated in this beam with BNCT (González et al., 2004, 2009; Menéndez et al., 2009).

During the years 2008–2011, and within the frame of the Reduced Enrichment for Research and Test Reactors (RERTR) international program, the Argentine RA-6 reactor's core reconversion process to operate with low-enrichment uranium was accomplished. Along this time, several planned modifications were implemented in the RA-6 BNCT facility, leading to significant benefits for future BNCT clinical treatments. The upgrades were meant not only to improve the spectral characteristics of the neutron beam and the treatment room capabilities (e.g., room dimensions, full degree of freedom positioning lasers, etc.), but also to integrate a protruding conical irradiation port to facilitate patient positioning during treatment. In order to continue with the clinical phase II trial started in 2003, an extensive quality assurance control has been performed comprising the physical and computational systems involved in the clinical treatment.

This work presents the improvements implemented in the clinically used treatment planning system, NCTPlan (González et al., 2002), and several computational dosimetry evaluations with the new beam (Longhino et al., 2012) (from now on, the "B2 beam") for two especially selected patients, treated between 2003 and 2007. Considering the results of these evaluations, a dosimetrical comparison

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with the former B1 beam is carried out, showing the present capabilities of the new BNCT facility.

2. Materials and methods

2.1. NCTPlan treatment planning system upgrade

In order to provide the necessary treatment plans for the continuation of the BNCT melanoma clinical trials in Argentina, new and superior capabilities have been implemented in NCTPlan treatment planning system, leading to its new version, NCTPlan v1.4. The most relevant features that were considered for this new version are the following:

- The integration of MPREP auxiliary code to the main architecture of NCTPlan.
- The possibility of dealing with neutron sources described in Track-by-Track (TBT) mode.
- The ability of managing volumetric representations of a wide variety of geometrical structures between the source and the patient (collimators, shields and additional filters).

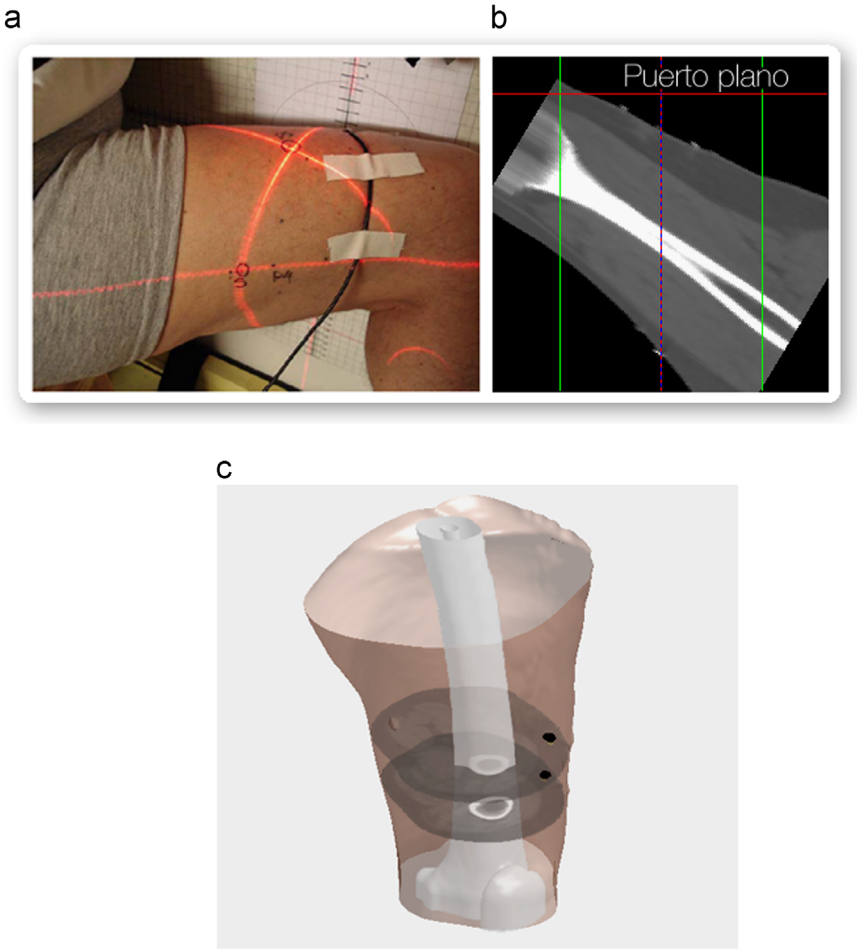

Fig. 1. Patient position during treatment verification (a) and NCTPlan v1.3 central axis view with the B1 beam port plane localization (b). Patient's computational reconstruction showing the position of both nodules (c).

Fig. 2. NCTPlan v1.3 coronal view (left) and sagital view (right) centered in the B1 beam entry coordinates. Patient position during treatment; Note that the foot limits the distance to the beam port (center).