Conference Paper

# Clinical Application of New Immobilization System in Seated Position for Proton Therapy

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## Abstract

In November 2015, the proton therapy complex "Prometheus", developed at PhTC LPI RAS, started being used for the clinical treatment of patients with head and neck cancer. A special mobile patient positioning and immobilization device has been developed within the proton therapy complex "Prometheus". The purpose of this paper is to report the first clinical experience of using new patient setup system in a seated treatment position.

**Keywords:** proton therapy, ion therapy, pencil beam scanning.

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## 1. Introduction

This device is much cheaper than a gantry and is suitable for a low-cost system designed to be used with a fixed treatment beam and a rotating seated patient. The system includes an armchair designed to fix the patient and move him to the irradiation zone, computed tomography system represented by a low-dose X-ray tube and a digital X-ray panel (detector).

With their help, the X-ray pictures are taken with a subsequent process of reconstructing them into a three-dimensional image for subsequent irradiation planning. The individual radiograph mode has been put into place in order to verify the patient's position before the start of the treatment. This paper reports the results of the verification (process that is carried out immediately before the proton therapy session) for the first 50 patients gone through clinical treatment at this facility. It contains a list of advantages of the presented system of patient positioning and immobilization in contrast to the standard methods and a gantry used in cases of head and neck cancer treatment. This system has been adapted for proton and ion therapy facilities working with the pencil-beam scanning (PBS) technique.

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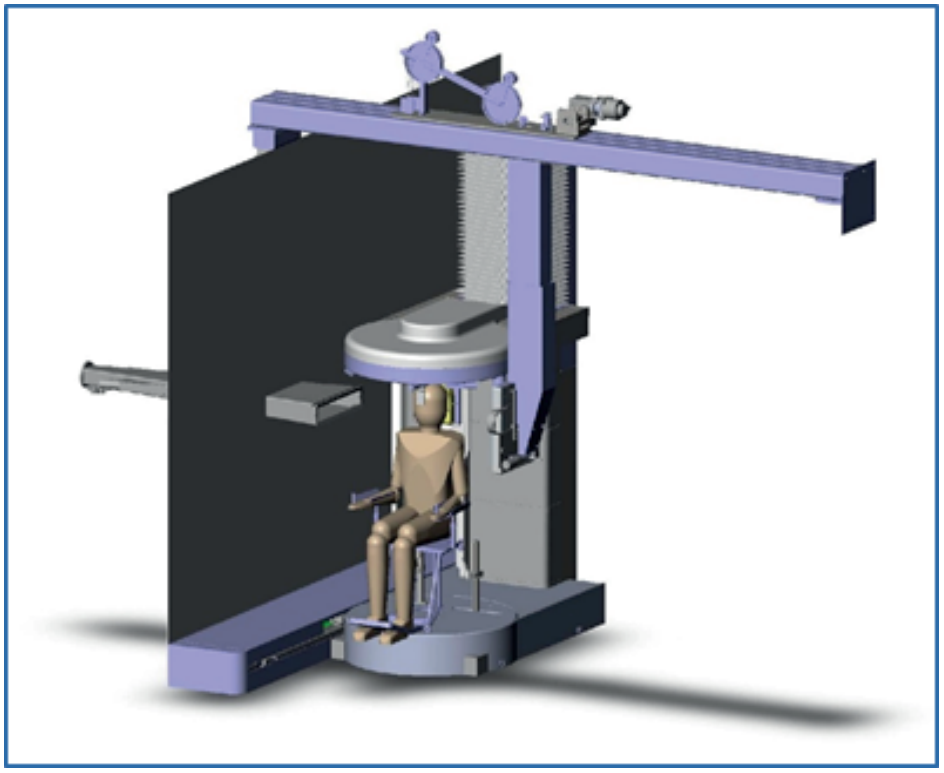


**Figure** 1: 3D-model of the immobilization system.

Table 1: Technical characteristics of the immobilization system.

| | |
|---|---|
| Dimensions (X, Y, Z), mm | 1530×3000×1840 |
| Max. power consumption | 600 W |
| Angle of rotation | 360° |
| Adjustment of patient's growth, mm | 500 |
| Control opportunities | direct (wired)<br>remote (wireless - Bluetooth)<br>remote (LAN) |
| Max. patient weight, kg | 135 |

## 2. Materials and Methods

The patient positioning and immobilization unit as a part of proton therapy complex "Prometheus", X-Ray cone-beam computer and CIVCO thermoplastic masks tomograph were used in daily verification procedures.

The process of the patient's verification in the immobilization system is carried out depending on the patient's condition and can be, either daily or up to two times a week. This process consists of preparing an X-ray, selecting irradiation angles from which the

patient's current situation will be compared with the planned one. According to the received images, an example of which is shown in Fig. 2, the patient's position in the immobilization system is adjusted.

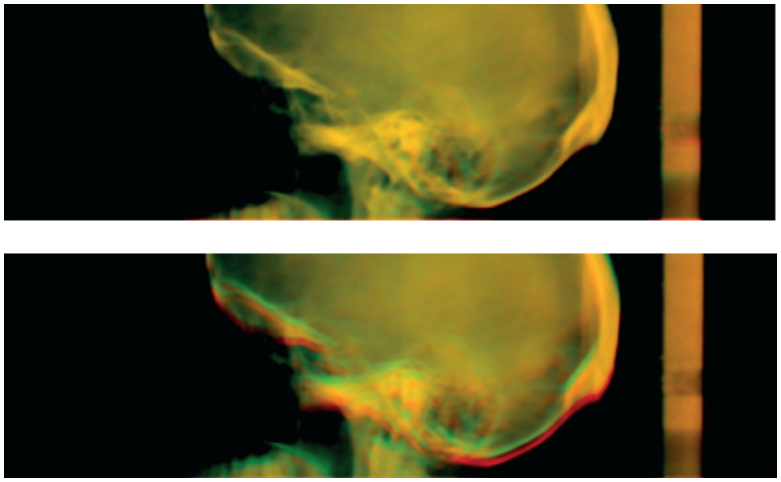


**Figure** 2: Patient position verification using X-ray CT.

The X-ray system is an integral part of the proton therapy complex "Prometheus" and is allowed not only to carry out the verification of the patient's situation, but also to make a full-scale CT for the further procedure of dose planning. The main characteristics of the X-ray system are shown in Table 2.

Table 2: Main properties of the radiographic system.

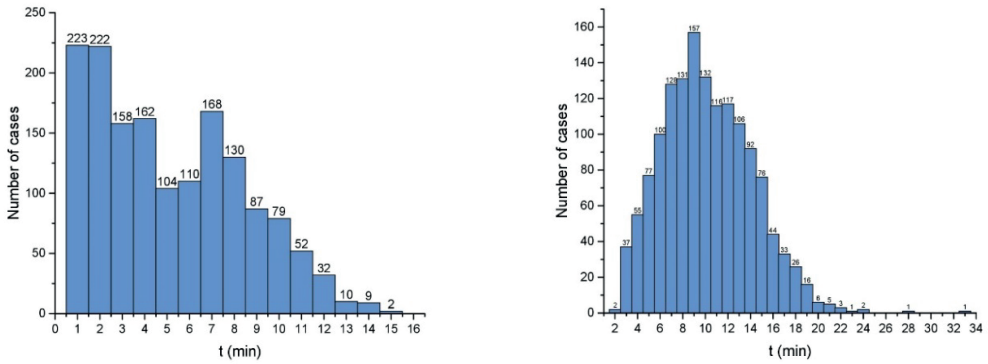
| | |
|---|---|
| The size of the X-ray detector, $cm^2$ | 40 × 40 |
| The pixel size, $mm^2$ | 0.2 × 0.2 |
| The system works in the modes | • "Snapshot"<br>• "Radiography"<br>• "Breath"<br>• "Verification" |

Thermoplastic masks (fig. 3) limits the patient's sudden movements during the irradiation procedure, but they have degrees of freedom up to 3-4mm. Because of this, during the verification procedure, we observe patient bias relative to the originally taken tomogram, which was used for planning treatment. Correction of displacements is carried out by moving the headrest and moving the entire platform on which the patient is immobilized in height.

**Figure** 3: Thermoplastic masks.

## 3. Results

The obtained results of patient setup displacement were slight. We got measurements for each of the dimensions: at the X-axis: -0.1±0.8 mm, at the Y-axis: -0.4±2.0 mm, at the Z-axis: 0.1±1.5 mm. 530 daily verification procedures were held for 50 patients. The average irradiation time of each treatment session was 5 min 39 sec (1548 cases). And the time finding a patient in the procedure room was 10 min 12 sec (1464 cases).




(a) (b)

**Figure** 4: Diagram of the irradiation time of one fraction (a), diagram of time finding a patient in the procedure room (A patient came into the treatment room and left it) (b).

## 4. Discussion

The immobilization system developed in the PhTC LPI RAS and Protom ltd. represents a good alternative to the most common gantry system [1] in the case of head and neck

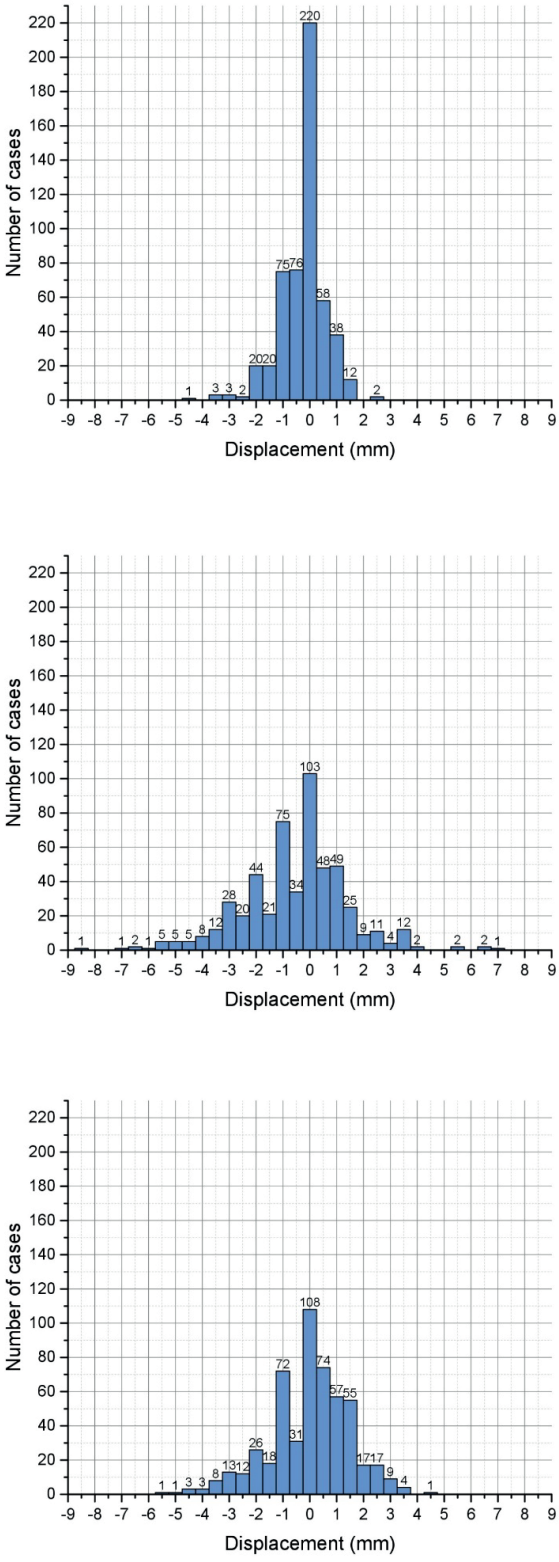



**Figure** 5: Patient setup errors: X-axis – top figure, Y-axis – middle figure, Z-axis – bottom figure.

cancer. Unlike the gantry, this system has a low weight, easy installation process and

a lower cost. These factors are critical for hospitals and cancer centers that want to start using proton and carbon radiotherapy instead of standard radiation therapy, and do not have the opportunity to erect a new building with a reinforced foundation. In addition, the use of such a system, as well as the entire complex of proton therapy "Prometheus", is a priority for single-room centers of proton therapy, since they make it possible to significantly reduce the cost of such a center. At the moment, the process of testing a new prototype of the immobilization system is underway, which will make it possible to irradiate neoplasms of any localization.

The development of low-cost immobilization systems for hadron therapy is an urgent task. An example of the work of the world's leading centers can be found in [2]. In addition, system of that kind has critical importance for patients who cannot undergo irradiation in a supine position.

## 5. Summary

This study demonstrates that the "Protom" patient setup system is a real alternative for gantry systems in cases of head and neck cancer. It meets all clinical requirements. This device can be used as an independent system of patient positioning and immobilization, or can be a part of complex facilities with gantries and other systems.

**Figure** 6: Immobilization system (Protvino city hospital).

## References

[1] U. Weinrich, "Gantry design for proton and carbon hadron therapy facilities", EPAC 2006.

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