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The Ion-Beam Radiation Oncology Center in Kanagawa (i-ROCK) Carbon Ion Facility at the Kanagawa Cancer Center

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Introduction

The Kanagawa Cancer Center (KCC) is the core facility for cancer care in Kanagawa Prefecture. It serves a population of more than 9 million people. Planning for the ion-beam Radiation Oncology Center in Kanagawa (i-ROCK) started in 2015. The basic framework and design of i-ROCK was established in 2010, and it is the first cancer-center-based carbon ion radiation therapy facility in the world and the fifth carbon ion radiation therapy facility in Japan. The building was completed in August 2014 (**Figure 1**). The installation of beam delivery equipment has been completed. The start of clinical operation is planned for December 2015. An overview of i-ROCK is presented in this report.

Clinical

Our facility's most distinguishing advantage lies in its location. The KCC is located in Yokohama City, capital of Kanagawa Prefecture, and one of the largest metropolitan areas in Japan. The population is 3.7 million in the city and 9.1 million in the prefecture. Our facility also has a regional advantage as it covers half of the greater Tokyo metropolitan area, which encompasses nearly 50 million people, as well as other surrounding prefectures. These areas are all within 1 hour by public transport. Thus, KCC stands at an ideal location for receiving outpatients from local and regional areas.

All of KCC's staff are specialists in cancer care. The protocols and treatment plans, including surgery, chemotherapy, radiation therapy, and their combination, are determined at a cancer board meeting, which is routinely held for each specific cancer. We will be able to offer a full range of treatment options and high-level services to patients with any type and stage of cancer.

The Department of Radiation Oncology currently operates 4 linear accelerators and has an image-guided brachytherapy system with an in-room computed tomography scanner. Thus, we will be able to provide carbon ion radiation therapy and precise photon radiation therapy, to any kind of cancer patient.

Outline of Facilities

After discussion of the conceptual design of the role of carbon ion radiotherapy in a cancer center, KCC contracted with Toshiba Corporation in 2012 to produce the

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Editorial

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Figure 1. Exterior of the Ion-Beam Radiation Oncology Center in Kanagawa.

system. The i-ROCK is a compact carbon ion facility for widespread use designed by the Japanese National Institute of Radiological Sciences [1, 2]. The facility is based on a synchrotron accelerator that feeds 4 treatment rooms (**Figure 2**). The specifications of the facility are shown in the **Table**. The treatment planning system was developed on the Monaco (Elekta) platform with algorithms for carbon ion dose calculation and pencil beam scanning optimization developed by the National Institute of Radiological Sciences. One characteristic of i-ROCK is that each treatment room has on-rail in-room computed tomography, allowing for verification of the internal target volume and critical organ position based on the calculated dose distribution.

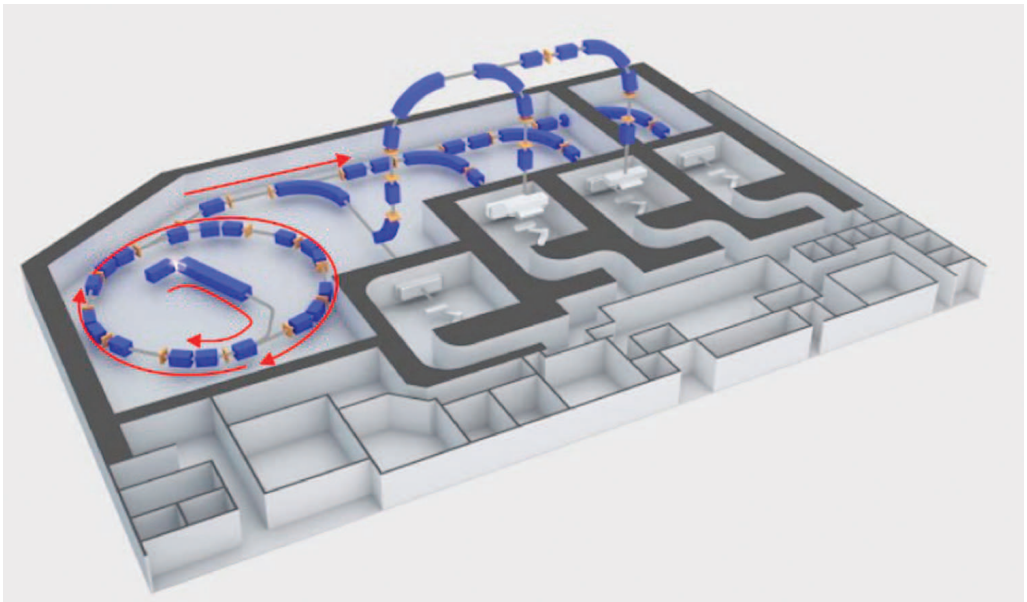

Figure 2. Internal layout of Ion-Beam Radiation Oncology Center in Kanagawa. The synchrotron ring diameter is 20 m, and the ion-source and injectors are set within the ring. The total floor size is about 70 m by 50 m.

Table. Specifications of the Ion-Beam Radiation Oncology Center in Kanagawa.

Ion species	Carbon ion
Maximum energy	430 MeV/u; Residual range > 25 cm in water
Range control	0.2 mm step; fine-range shifters with multistep variable energy
Beam delivery	3-dimensional pencil beam fast scanning
	Irradiation field; 200 × 200 mm
Number of treatment rooms	4 rooms with fixed beam port; 2 with horizontal and vertical beam ports, 2 with horizontal beam port
Treatment couch	Robotic couch with 7 degrees of freedom
Patient positioning	Orthogonal x-ray flat panel detector imaging system
	Rail-on in-room computed tomography

Current Status

We succeeded in accelerating the carbon ion beam to maximum output energy in January 2015. In February 2015, we achieved an 11-step energy and scanning control of the pencil beam. In the same month the facility passed the government safety inspection for particle radiation therapy facilities. We will start carbon ion radiation therapy using spot scanning method, and i-ROCK will be the first specialized facility for the scanning method of carbon ion radiation therapy in Japan.

ADDITIONAL INFORMATION AND DECLARATIONS

Conflicts of Interest: The authors have no conflicts to declare.
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