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Case report

Skin surface markers for stereotactic body radiation therapy of sternal metastasis

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ABSTRACT

Stereotactic body radiation therapy is an effective and safe treatment modality for bone metastasis which allows clinicians to accurately target lesions to high doses while minimizing dose to organs at risk. The commercially available CyberKnife® Xsight™ Spine Tracking System (Accuray, Inc., Sunnyvale, CA) tracks static skeletal structures and eliminates the need for implanted fiducial markers (FMs). However, the Xsight™ Spine Tracking system is not appropriate for bone metastases outside the spine, which are moving due to respiration and ,typically, FMs have to be implanted close to the lesion. These FMs will be used to track the dynamic target. For targets close to the surface, non-invasive fixation of the FMs to the patient's skin could be an option.

1. Aim

The purpose of this study is to report two cases with sternal metastases treated in our institution with robotic radiosurgery, where we attached the FMs non-invasively to the patient's skin.

2. Background

Bone is one of the most common sites of metastatic disease in cancer patients and can cause debilitating effects including pain and pathological fracture. Bone metastases can be treated medically (analgesics and bisphosphonates), surgically, or with radiation therapy.[1] Typically, conventional external beam radiotherapy (cEBRT) has been the mainstay treatment modality for painful bone metastases, using palliative doses of irradiation.[2] These doses, however, have proven to yield partial pain relief and improve quality of life as opposed to complete pain relief and durable long-term local control.[2] Both from a technological and medical standpoint, stereotactic radiotherapy (SBRT) for bone metastases is a fairly new option for the treatment of oligo-metastatic/progressive disease which delivers higher biologically equivalent doses (BED) as compared to cEBRT.[3,4] The majority of published studies regarding SBRT for bone metastases focus on treatment of spinal metastases.[5] In terms of non-spine bone metastases, there are few retrospective studies utilizing SBRT, and large series are missing.

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The frameless robotic radiosurgery system CyberKnife® Xsight™ (Accuray Inc., Sunnyvale, CA) implements real-time image guidance to track the target during the procedure,[6] using bone landmarks instead of implanted fiducial markers (FMs). However, this tracking system was not developed for non-spine bone metastases, where the position is subject to change with respiration. In this case, FMs have to be implanted within or close to the target to track the dynamic target. Depending on the site, FM placement can cause complications such as pain, pleural effusion and hematuria as well as some technical problems, like migration of FMs.[7]

In this study, we report on two patients with sternal metastases who were treated with SBRT using the CyberKnife®, where we attached the FMs non-invasively to the patient's skin. The informed patient consent was obtained in both cases before the therapy.

3. Case presentation 1

A 57-years-old male patient had an eight-year history of follicular thyroid cancer, and was initially operated with total thyroidectomy and neck dissection. The operation was followed by radioactive iodine therapy under thyrogen stimulation. A lymph node/soft tissue relapse occurred in the supraclavicular region four years after initial diagnosis. The revision neck dissection was performed and the region was irradiated up to 66 Gy with 2 Gy dose per fraction due to R1-Situation. Three years after the first relapse, the ^{18}F fluorodeoxyglucose positron emission tomography and computed tomography (^{18}FDG-PET/CT) and a magnetic resonance imaging (MRI) on T1w-/T2w sequences showed a solitary bone metastasis in the manubrium sterni with 8 mm diameter, otherwise no further metastases. The patient was symptomatic in terms of mild pain in the upper third of the sternum (VAS 2), although the pain was tolerable without pain medications. Based on multidisciplinary tumor-board decision and taking into account the normo-fractionated irradiation to first relapse (66 Gy), which overlapped totally with the new sternal metastasis, we offered the patient a SBRT with 3×8 Gy at our robotic radiotherapy unit using skin surface markers in three consecutive days. The markers, four in this case, needed to track the tumor with the aid of the Synchrony™ Respiratory Tracking system, were attached non-invasively to the patient's skin close to the sternal metastasis (range: 17–40 mm) in a supine position. According to CyberKnife Treatment Delivery Manual (Version 11.0.X), the maximum distance between the FMs and the target should not be more than 5–6 cm. It is important to place the FMs in such a way that all FMs are later visible on the kV-images at the treatment unit. There should be a minimum spacing between two markers of 20 mm and the angles of the triangles defined by three markers should not be smaller than 15° (non-collinear). The locations of FMs were identified on the skin, using diagnostic CT and MRI images. To avoid dislocating the markers, the locations were tattooed and the FMs stuck on the skin before every treatment fraction. A planning target volume (PTV) margin of 3 mm was used. From this point on, the treatment preparation as well as the treatment itself were performed in the same way as for a patient with implanted FMs treated with the aid of the Synchrony® Respiratory Tracking system. The first ^{18}FDG-PET/CT was done 3 months after the treatment and showed metabolic and morphologic progression of the sternal metastasis, although the pain remained unchanged. The second ^{18}FDG-PET/CT 6 months post-SBRT showed metabolic regression and stationary morphologic changes of the lesion, which was interpreted as a clinical treatment response. The thyroid hormone therapy with Euthyrox remained unchanged during and after the SBRT. Clinically, the patient showed a partial pain response at the last follow-up (6 months after SBRT) feeling still some light pressure in the mediastinum.

4. Case presentation 2

An 84-years-old male patient with a 26-year history of malignant melanoma was initially resected at the primary site of the tumor on the distal part of the left thigh. After resection, the patient was observed for the next 25 years until he experienced a relapse on the proximal part of the left thigh. The tumor was resected but the follow-up ^{18}FDG-PET/CT showed a second relapse 8 months after the surgical resection again on the left thigh. The recurrent tumor was resected widely and the patient had adjuvant immunotherapy with Nivolumab until he developed a solitary sternal metastasis after the second relapse. The lesion was diagnosed in the ^{18}FDG-PET/CT, and the multidisciplinary tumor-board recommended SBRT for the bone metastasis as well as second-line immunotherapy with Pembrolizumab. Regarding sternal metastasis, the patient was asymptomatic before irradiation and no pain could be triggered with pressure. The FMs were again attached to the skin, near the sternal lesion (18–28 mm) and the metastasis was irradiated with 3×8 Gy in three consecutive days. Unfortunately, 4 months later, the patient developed bilateral pulmonary metastases. The bone lesion in manubrium sterni showed morphological progress on diagnostic CT, without clinical correlation. Therefore, we interpret these radiological findings in the sternum as radiation-induced changes and not necessarily as tumor progression.

5. Discussion

Bone metastases are frequent among cancer patients and typically indicate a poor prognosis.[8] In recent years, SBRT has appeared as an effective, safe and established treatment modality for bone metastases, especially for spine lesions,[9] while the data regarding SBRT for non-spinal bone metastases is limited. The spine metastasis could be treated using the Xsight™ Spine Tracking System at CyberKnife®, which localizes the target by direct reference to the adjacent vertebral elements, but implanted FMs are needed for tracking the movements of non-spine bone lesions during stereotactic radiotherapy.[10] The FMs are often implanted under image-guidance in the close vicinity of the lesions, but the procedure could encounter different challenges and complications like pneumothorax, bleeding, migration of FMs, etc..[11] In the present study, FMs were attached to the chest skin around the sternal lesions before every fraction of radiotherapy. The skin surface markers were detected without any difficulties using

the Synchrony® Respiratory Tracking system at CyberKnife®. To our knowledge, this is the first report describing the application of skin surface markers to perform SBRT for non-spine bone metastasis. The skin-attached FMs eliminate the implantation procedure and, thus, could save the time as well as prevent peri- and post-interventional complications, such as pain and infection.

Financial disclosure

None declared.

Conflict of interest

None declared.

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