CASE STUDY

RECURRENT MULTIPLE MYELOMA AT CLIVUS & C1

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**Case History**
This 43-year-old male had an extended history of multiple myeloma. He was initially diagnosed when he presented with a severely destructive lesion at C1, which was treated with external beam radiation to the neck to 45 Gy. Two years later, he had recurrent disease, which was first treated with VAD (vincristine, adriamycin and dexamethasone). This was followed by a stem cell transplant preceded by high-dose cyclophosphamide plus etoposide and high-dose melphalan. He then was retreated with external beam radiation to 36 Gy with the spinal cord blocked. His disease progressed, and two years later, he underwent a 3-phase surgical resection with occipito-cervical fusion with internal fixation. The next year, he underwent a bone marrow transplant. The patient had been stable for several months, when MRI showed increasing soft tissue mass involving the clivus and skull base, right greater than left.

**CyberKnife® Treatment Rationale**
This patient had been treated twice with radiation, chemotherapy, stem cell transplant and surgery. Additional external beam radiation would have exceeded normal tissue tolerances. CyberKnife® treatments, with submillimeter\(^2\) accuracy and highly conformal dosimetry, was the only reasonable option to control the patient’s tumor without causing undue radiation-induced toxicity.\(^1,3\)

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**Planning CT images (1.25 mm) showing the extent of disease in the axial plane covering 3 cm of cranial-caudal anatomy.**

**Axial and sagittal T1 MR with gadolinium contrast at the level of the clivus and C1 compressing the brainstem and upper cervical spine on the right side. This imaging study reveals a 4.8 x 2.9 x 2.8 cm mass extending to the right occipital condyle, the anterior arch of C1 and the superior body of C2, including the dens on the right side.**
Planning Process and Goals
Fiducials were placed in the C2 spinous process, C3 spinous process, C5 lateral mass bilaterally, and the occiput. The patient was supported supine by a soft "timo-B" head rest and immobilized with a head-only Aquaplast mask. A contrast-enhanced CT scan was performed.

Treatment Delivery
To accurately track and correct for patient movement during treatment, images were taken every other beam. Critical structure doses were designated as follows: a) maximum dose to brain stem/spinal cord was 26.54 Gy; 1 cc of brainstem/spinal cord received ≥ 15.0 Gy; 0.1 cc of brain stem/spinal cord received ≥ 21.75 Gy; b) maximum dose to the right inner ear was 23.20 Gy; 1 cc of inner ear received ≥ 7.9 Gy; 0.1 cc of inner ear received ≥ 16.1 Gy; c) maximum dose to the mucosa was 22.41 Gy; 1 cc of mucosa received ≥ 13.73 Gy; 0.1 cc of mucosa received ≥ 18.5 Gy.

<table>
<thead>
<tr>
<th>TREATMENT DETAILS</th>
<th>Fractions: 5</th>
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<tbody>
<tr>
<td>Tumor Volume: 29.14 cc</td>
<td>Path Template: 3 path 900_1000 mm</td>
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<tr>
<td>Imaging Technique(s): CT, MRI</td>
<td>Tracking Method: Fiducial</td>
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<td>Rx Dose &amp; Isodose: 30 Gy to 52%</td>
<td>Collimator(s): 15 mm</td>
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<td>Conformality Index: 1.30</td>
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<td>Tumor Coverage: 75.9%</td>
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<tr>
<td>Number of Beams: 229</td>
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</table>

Axial and coronal planning images showing the delineated tumor volume (red) as well as the critical structures of brainstem (green), inner ear (yellow) and mucosa (blue).

Right inferior oblique 3D rendering of bony anatomy and CyberKnife beam positions.

Dose Volume Histogram (DVH) for all key structures.
Outcome and Follow-Up
• The patient tolerated the treatment well with no adverse side effects
• The patient responded to CyberKnife® treatment with a decrease in the size of his right cervical mass for the next 11 months
• Eleven months post-treatment, he developed a new mass in the sacrum, which was treated with conformal external beam radiation to 54 Gy with good clinical response
• Twenty months post-treatment an MRI of the neck revealed recurrent disease in the left neck, outside the volume previously treated with the CyberKnife System Disease extended from the left occipital condyle to the left C2 lamina with mild enhancement; he was treated with the CyberKnife System to the new lesion, receiving 20 Gy in 5 fractions prescribed to the 70% isodose line
• Follow-up MRI at 21 months showed a decrease in size of the mass; the patient continued to do well with occasional mild neck pain with no other neurological symptoms; at the 32-month follow-up, the patient showed stable disease

Conclusion and CyberKnife Advantages
• The CyberKnife System is useful for treating soft tissue lesions in the spine\textsuperscript{1,3} that are inoperable or for which the maximum dose to the cord has already been given using standard radiation therapy approaches
• With high dose conformality the CyberKnife System has the ability to tightly target the tumor\textsuperscript{2} with an ablative dose of radiation and a corresponding minimal dose to critical structures of spinal cord and brainstem

Post-treatment CyberKnife images taken 20 (middle) and 32 (right) months after the pretreatment images (left) demonstrates complete regression of the right-sided mass (orange line) representing local control of the tumor. A left-sided recurrence (middle - yellow line) outside the treated volume, which was also treated by CyberKnife, subsequently shows a similar response 11 months later (right).

References