A New Patient Support Pad for CyberKnife Planning & Delivery - A Technical Note

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Abstract

For CyberKnife planning and treatment, patients are set up on a thin foam pad. In the head first supine position, the patient's arms are at body level at their side for treatment. This position of the arms does not allow beams to be planned and delivered that transit the arms if arm avoidance is desired. To circumvent this problem, a new thicker, firmer patient support pad has been developed and used to treat many patients at our CyberKnife Centers. The new pad is narrower at the level of the trunk and abdomen allowing the patient's arms to fall comfortably below body level. This allows more beams to be planned using the plan optimization routine to enter the body from more posterior-lateral directions than can be obtained with the patient on the thin pad. Illustration of the use of the new pad and an example plan is discussed.

Categories: Radiation Oncology, Medical Physics

Keywords: cyberknife, arms, patient support pad, treatment delivery, treatment planning

Introduction

Patients being prepared for stereotactic radiosurgery (SRS) and stereotactic body radiation therapy (SBRT) procedures with the CyberKnife (Accuray, Inc., Sunnyvale, CA) robotic therapy system have typically been set up on a thin, foam pad support or some form of body immobilization device. Head first, supine is the most frequently utilized body position for treatment, although other positions may be used (e.g., feet first, supine, for treating prostate cancer). Invariably, the patient's arms fall at body level along the lateral aspects of the body, usually touching the body along this direction. Immobilization devices, although effective at keeping patients still during conventional radiation therapy fractionation schedules for a few minutes per irradiation, are less advantageous for the longer duration treatments for the hypofractionated schedules and higher dose/fraction used in SRS and SBRT procedures. These treatments may be delivered over time frames of one hour, more or less, and we have found that patients "fidget" in immobilization devices for these time frames. We find that patients do better at keeping still during SRS/SBRT delivery if they are allowed to lie comfortably on the thin foam pad during treatment delivery. The patient's arms, however, fall laterally at their sides with this CyberKnife method of treatment, and this position of the arms prohibits the use of beams transiting the arms. A typical beam arrangement (light blue lines) is seen in the rendered CT data set in Figure 1. Hence, beams must enter the body, in the region of the trunk of the body (mid-thorax through lower abdomen), in an anterior solid angle, chiefly, as seen in Figure 1. The CyberKnife treatment system does not allow posterior beam directions at this point in the evolution of the system, even though these beam directions would be advantageous for many treatment sites (spine, posterior tumors, etc).

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FIGURE 1: 3D rendered image of CyberKnife plan.

The light blue lines indicate beams/directions. Note that beams are not allowed to transit the arms in this plan case.

Another point to make here is that, for larger patients, the arm images are “cut-off” in the small aperture CT scanners used to acquire plan data. Beams cannot be used to enter the patient through these “cut-off” directions, since there will be a substantial error between the plan and actually delivery of dose in these directions. Hence, the CT images of the arms, whether “cut-off” or whole are many times contoured for planning as “avoidance” structures and beams are not allowed to penetrate through these avoidance structures in generating the treatment plan. This severely limits the allowable beam directions in the planning optimization routine and can result in sub-optimal plans.

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Patients' arms that are in the way of a radiation therapy procedure have been dealt with many times. Again, for the relatively short treatment times encountered in conventional radiotherapy, Figure 2 shows one method (Wing Board) of bringing the patient's arms away from the body for both CT scan acquisition and treatment delivery [1-2]. Again, this method would not be useful for the more lengthy SRS or SBRT procedures for patient comfort. Also, the elbows may not fit through the smaller CT apertures for plan data acquisition.

FIGURE 2: A patient is set up for radiotherapy course using the “Wing Board”

A patient is set up for radiotherapy course using the “Wing Board”. This is one method of moving the arms away from the body for treatment in conventional radiotherapy.

For CyberKnife procedures, we propose using a thick foam pad; one that is firmer than the current thin patient support pad. The thin pad is not used when this thicker pad is employed. The thicker pad is constructed narrower than the flat treatment couch top at the level of the patient's trunk and allowed to expand to full couch top width at the hips for comfort. In this position, shown in Figure 3, the patient's arms are seen to fall comfortably at their side and below body level. Now, as can be appreciated from the figure, one can imagine many beams entering the trunk of the body, if necessary, from more posterior-lateral directions. Indeed, these beams can be efficiently employed for both posterior central structures, such as vertebral body tumors, and for lateral tumors of the liver or other abdominal lesions. Figure 4 shows the new pad in place on the treatment couch.

FIGURE 3: Patient set up for CyberKnife treatment on the new thick pad.

Note the arms resting comfortably on the flat couch below the patient's body. This attitude allows more posterior-lateral beams to enter the trunk area of the body without transiting the arms.

FIGURE 4: The appearance of the new thick patient support pad on the flat CyberKnife couch

The appearance of the new thick patient support pad on the flat CyberKnife couch. Note that the pad is narrow at the superior end of pad and widens at the hip area of patient.

Figure 5 demonstrates again the allowable beam directions on an axial CT slice of a patient plan data set with the patient positioned on the conventional thin pad with white arrows demonstrating beams that might be used in treating a vertebral body tumor, for example. The beams are not allowed to transit the arms of the patient at his side. Note that some of the beams will likely transit the spinal cord and contribute dose to this critical structure.

FIGURE 5: Axial planning CT slice with patient on thin pad.

Note the arms at body level forcing beams (white arrows) to enter through small anterior solid angle to vertebral target in this case.

In Figure 6, a similar axial CT slice is presented but now with the patient supine on the new, thick support pad. Note that the arms are visualized on the CT slice below the level of the body. The white lines again present possible CyberKnife beam directions, but now the optimization routine can choose beams that do not necessarily transit the spinal cord – allowing a lower dose to this critical structure than attainable with the patient lying on the thin pad. The arms will likely still be required to be contoured as “avoidance” structures, but the solid angle for allowable beams for the planning optimization routine to work with has increased significantly!

FIGURE 6: Similar planning CT slice as in Figure 5, but now patient is set up on thick pad

Similar planning CT slice as in Figure 5, but now patient is set up on thick pad. Note the arms are now below body level and more beams (white arrows) can enter through posterior-lateral directions to the vertebral body.

Discussion

In designing the new patient support pad, several thicknesses were attempted. The final version is approximately 10 cm thick (~4 in.). When thicker pads were attempted, the arms began to fall below the body at an angle that became uncomfortable for most patients. In addition, the thicker pads (6 & 8 in. thicknesses were tried) brought the patient up too high from the flat couch top such that CT scans began to “cut-off” some of the anterior portions of the body – again, a condition that would not allow beams to enter in these directions without plan/dose errors. Thinner heights of the pad brought the arms close to body level once again, a condition that mimicked the thin pad with its difficulties discussed previously. We also tried narrower versions of the pad at trunk level, but these widths were unnecessarily narrow and we settled on the width shown in Figure 4. Our CyberKnife plans using the new patient support pad more efficiently utilize the available beams through the plan optimization routine now. Figure 7 illustrates a vertebral body tumor plan with much less dose to the spinal cord with patient lying on the new, thick support pad. Figure 8 illustrates a similar treatment plan with the patient lying on the conventional, thin support pad. Note the arms at body level with the right arm contoured as an avoidance structure, disallowing beams to enter laterally from this direction.

FIGURE 7: Appearance of 3D CT rendition of CyberKnife treatment plan targeting a vertebral body tumor using thick pad

Appearance of 3D CT rendition of CyberKnife treatment plan targeting a vertebral body tumor using thick pad. Note the good coverage of tumor with low spinal cord dose. The light blue lines indicate beam/directions in upper left frame that are allowed to enter posterior-laterally into the body.

FIGURE 8: Typical Spine plan with patient on CyberKnife thin support pad

Typical Spine plan with patient on CyberKnife thin support pad. Note the CT scan “cut-off” on the right arm. This structure was contoured as a beam avoidance structure – disallowing beams to enter through this direction resulting in a higher spinal cord dose for this case.

At the present time, it is not clear how the MultiPlan optimization routine will utilize the fact that larger solid angle access to beams entering the body will be made available with the new pad. Accuray may wish to use the information that, for example, posterior-lateral access to a hepatic lesion is available because the new pad is being used – and these beams and directions can be weighted more heavily in the optimization routine. A “pad on/off” switch may be made available on the software to indicate that the pad is being utilized for a particular patient.

Conclusions

A new patient support pad has been described for CyberKnife planning and treatment delivery. This pad is thicker than the conventional support pad currently used in centers and allows the patients arms to fall below the body, such that more posterior-lateral beams can be chosen by the plan optimization routine with which to treat the patient. These beams are delivered in a more efficient manner. We typically use the pad when the lesion to be treated lies posterior to and inferior to the carina. This is only a rule of thumb that we use and have treated some lesions in the liver, for example, anterior to this level successfully.

Although we have described the use of this new patient support pad as being very useful for planning and delivering CyberKnife beams, the pad may be useful in a number of medical procedures that seek to move the patient’s arms out of the way comfortably during the procedure. For example, hepatic access for ultrasound exams or minimally invasive procedures for liver or other abdominal access could be accomplished easily and comfortably for patients through the use of the thicker support pad. One last note for CyberKnife planning and treatment delivery must be emphasized. The same pad that the patient will be treated on must be used in obtaining the CT data set for planning or the geometry will not be accurately portrayed for the patient treatments.

Additional Information

Disclosures

This study did not involve human participants or tissue. This study did not involve animal subjects or tissue. **Conflicts of interest:** The authors have declared that no conflicts of interest exist except for the following: **Intellectual property info:** A provisional patent was applied for, but a permanent patent was not prosecuted. **Other relationships:** James Hevezi constructs and sells the Pad described in the paper to CyberKnife users that request it.

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