Orthovoltage X-Ray Minibeams: Potential for Treating CNS Cancers with Minimal Damage to Superficial Tissues

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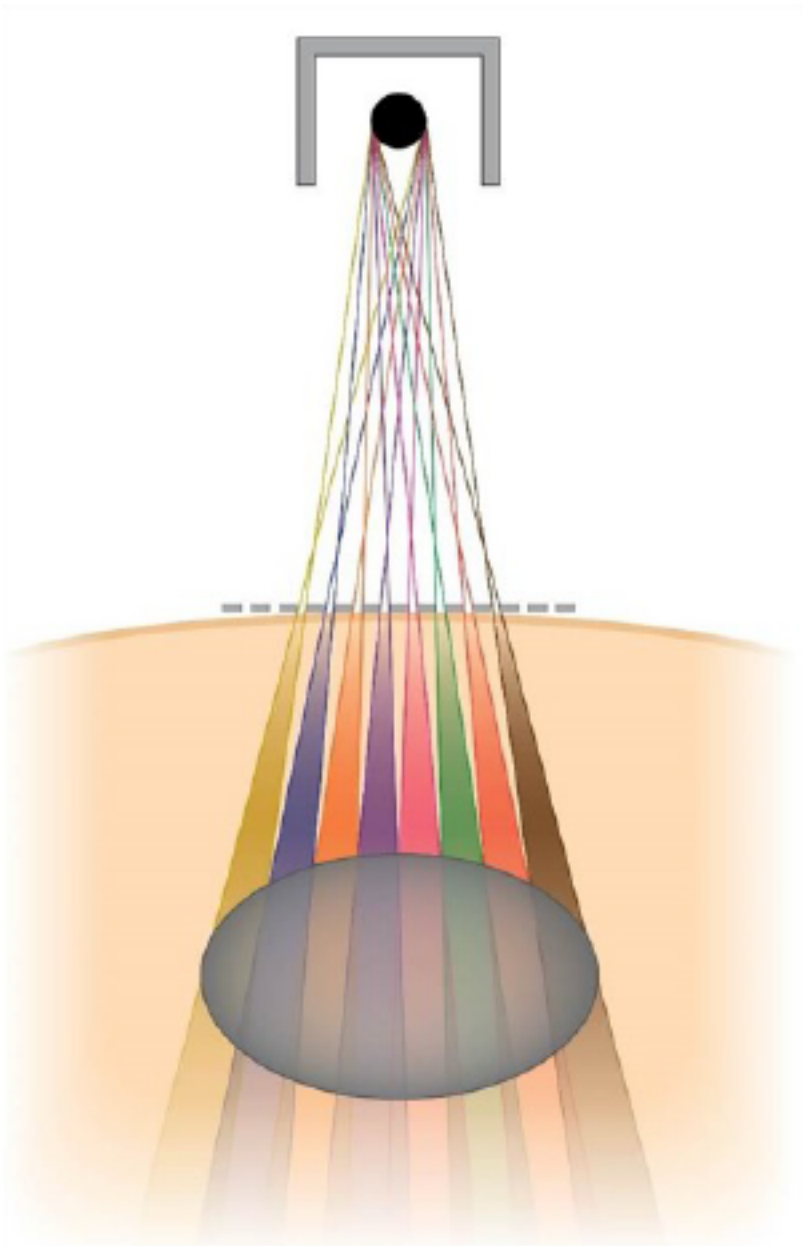
OBJECTIVES: Most current radiation therapy methods for primary or metastatic brain tumors use megavolt (MV) photons produced by linear accelerators or Cobalt-60 sources, which replaced the 250-kVp orthovoltage x-rays used at the beginning of the 20th century. Although the methods are effective in controlling tumors, nearly all pediatric patients and a significant number of adults undergoing brain tumor radiation therapy still develop some level of late neurocognitive deficits largely due to cerebral cortex damage. The experimental method Orthovoltage X-Ray Minibeams (OXM) has the potential to solve this problem.

METHODS: OXM uses segmented orthovoltage x-ray beams called minibeams; these are arrays of parallel, thin (~0.3 mm incident beam thickness) planes of x-rays produced by sources of up to 320-kVp. The method is based on the remarkable tissue-sparing effect of x-ray minibeams, and their thinner counterparts called x-ray microbeams; this effect has been shown in a wide range of studies using synchrotron x-rays. As a result, x-ray minibeams eliminate the large proximal dose which is characteristic of solid-beam orthovoltage x-rays. OXM's design considerations include the x-ray source spot size and the distance between the source and the multislit collimator, which cause the minibeam arrays to slightly diverge. This beam divergence makes the minibeams gradually thicken as they depart from the multislit collimator (See Figure).

RESULTS: Using appropriate design, the minibeams merge with their neighbors at the proximal side of the target to produce a solid beam. Because OXM uses a lower beam energy than MV x-rays, its beam's interactions with tissues have a higher probability of photoelectric absorption. Furthermore, its Compton Scattering produces less energy transfer to secondary electrons. Because of these two effects, OXM produces a smaller exit dose from the target and a much sharper lateral dose fall-off compared to MV x-rays. OXM could also be implemented in arc-scan geometries and in IMRT routines with the gantry's rotation axis situated parallel to the planes of incident radiation.

CONCLUSIONS: OXM's kilovolt beam energy makes it ideal for tumor-dose enhancement with high-atomic-number contrast agents; its low cost, portability, and lower room-shielding requirements make it ideal for use in low- and middle-income countries.

Figure on next page.



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