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EDITORIAL

Gamma Knife, CyberKnife or micro-multileaf collimator LINAC for intracranial radiosurgery?

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The number of publications comparing the various technologies for intracranial radiosurgery is increasing slowly but steadily. Treatment plans of various equipment using photon beams have been compared directly for radiosurgery of arteriovenous malformations [1, 4, 5], acoustic neuromas [3, 5], brain metastases [8], trigeminal neuralgia [2], various pathologies [7] and a simulated ellipsoidal target [9]. Since proton-beam therapy is not applied as a single-session radiosurgery, it is not discussed. The authors of this issue's contribution, "Dosimetric comparison of different treatment modalities for stereotactic radiosurgery of meningioma" (Kaul et al. [6]), undertake an interesting and important further step in the comparison of three different radiosurgical technologies. They compare radiosurgical plans generated on the three different platforms for the treatment of meningiomas. Radiosurgical treatment plans for ten meningiomas are investigated using Gamma Knife (GK) technology, CyberKnife (CK) technology, and the micro-multileaf collimator system of the Novalis linear accelerator (MML). All ten patients have been treated with the CK. In that sense, the CK plans are real life plans and the GK and MML plans are sham plans. Unfortunately, the tumour volumes are rather large and the prescription dose (PD) seems rather high. In that sense, the study may not necessarily reflect typical cases. The nature of the study leads to an investigation which remains on a technical level and it does not take radiosurgical issues into account such as differences in: dose rates, radiation source, radiation spectrum, planning paradigms, isodose lines to which the PD is typically applied in the various systems, etc. In this setting with an identical PD, the authors find no differences in tumour coverage for the three technologies and no differences in conformity index between GK and CK technologies. The gradient index which indicates the steepness of the dose fall-off outside the target is best for the GK technology; on the other hand, beam-on-time is longest for the GK technology. Personally, I find it rather unlikely that as in this issue's study by Kaul et al. [6], identical meningiomas would be treated with identical treatment parameters such as PD or treatment plans with the three various systems in question. The experienced neurosurgeon who uses one or another technology is aware of inherent diverging factors of the various technologies such as dose rate, which is at least 5 times higher in CK technology than in GK technology and adjusts his or her decisions accordingly. In my view, an excellent or good GK plan is not necessarily an excellent or good CK plan and vice versa. It is important that the radiosurgeon is aware of that. Ideally, the radiosurgeon is familiar with more than just one technology which allows him or her to adjust for the necessary clinical decisions.

Since the present and most of the former trials focus on dosimetry, the nature of dosimetry needs to be looked into more closely. What is dosimetry? Dosimetry is the calculation and the assessment of the radiation dose received by a target and organs at risk. Dosimetry is the result of a number of parameters constituting a given radiosurgical system—including its users. A non-exhaustive list of those parameters includes: the source of the photon radiation (cobalt-60 or linear accelerator); the nature of the collimators (fixed aperture, iris, micro-multileaf, etc.); moving or stationary radiation sources during beam-off time or beam-on time; the fixation of the head; the planning software; the imagery used; the way the images are acquired (dedicated protocols, head fixation, etc.); the number of beams; the number of arrival angles; the exit dose; the scatter factor of a given beam; the distance source to target; the time period over which a dose is delivered; the system's overall accuracy; dose rates; the nature and the size of the lesion; the shape of the lesion; its proximity to organs at risk; and last but not least, the experience and the

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neurosurgical and anatomical knowhow of the radiosurgeon. Dosimetry can be measured with parameters such as target coverage, conformity index, gradient index, isodose lines, scatter factors, beam-on time, homogeneity, the system's geometric accuracy, dose rates; dose delivered to organs at risk, dose delivered to distant parts of the body, etc. How do such differences in dosimetry within the rather narrow range which may be encountered with the various technologies for intracranial radiosurgery influence clinical outcome? That question still needs to be answered.

While the focus on dosimetry is certainly legitimate, it shifts away the attention from other and probably not less important issues. Ultimately, dosimetry results from a combination of various parameters of which the authors have investigated a select few. In many ways, the differences between the various technologies are of a more fundamental nature and include parameters such as monoenergetic radiation versus radiation of a wider spectrum, inverse planning versus multi-isocentre planning, head immobilisation with a stereotactic frame versus a thermoplastic mask during image acquisition or therapy; in addition, prescription isodose lines typically vary between the systems, etc. As an example, the significance of those differences will be obvious considering just the shape of the target or the intended lesion. The shape itself may influence treatment planning, dosimetry, outcome, and ultimately the choice of the radiosurgical technology to be used for a treatment. With the GK it is easier to accomplish a small spherical lesion with a diameter of 6 mm, a dose maximum of 140 Gy and a steep dose fall-off within the brain as required for the treatment of movement disorders, while it may be easier to cover a stretched and lengthy target volume with the CK as it may be necessary for the treatment for paraoptic meningiomas. In other words, the present and most of the former studies are important first steps in comparing various radiosurgical technologies and hopefully they will be followed by more comparative trials. The current investigation should not be misread in the sense that the differences between the various radiosurgical techniques can be reduced to the technical aspects presented by the authors. It will be interesting to see if the sum of all the parameters including the ones investigated by the authors lead to differences in clinical outcome following radiosurgery with the various technologies in question. The correct indication may be more important than technological aspects of a given radiosurgery system. In the end, what probably matters most may not necessarily be the equipment itself but the one who uses it.

Conflicts of interest None.

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