Which measurement type should be used for disease control of brain metastasis, volumetric or linear?∗

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**Aim and objectives**

The ideal quantification method for tracking disease progression of brain metastases has been controversially discussed in the relevant literature. In 2015 the RANO group proposed a method in which RECIST 1.1 (Eisenhauer et al. 2009) and the RANO criteria for high-grade gliomas (Wen et al., 2010) were used as a baseline to form new criteria to standardize brain metastasis quantifications (Lin et al., 2015). The proposed quantification relies on unidimensional measurements of contrast enhanced lesions in a single plane that have a minimum diameter of 10mm at the largest measurable site (Lin et al., 2015). However, even within these proposed criteria, the RANO group has discussed the possible advantages of a three-dimensional approach of measuring the progression of brain metastases. Since there are very few studies that focus on comparing the types of measurements, it cannot be conclusively decided which method is better for disease tracking in clinical use. Therefore, this study set out to clarify this by analysing 55 patients with brain metastases before and after SRT using the RANO−BM criteria (Lin et al., 2015) and the volumetric criteria proposed by Matthew J. et al. 2012 (Follwell et al., 2012).

**Methods and materials**

The studies were performed with Osirix on gadolinium contrasted T1 weighted MRI images and analysed using Microsoft Excel. The RANO−BM criteria were applied to the 2d measurements whereas 3d measurements were categorized according to Matthew J. et al. 2012 (Follwell et al., 2012).

**Results**

The overall survival time after the first SRT was determined to be 13.8 months but the partial responders had a clear advantage with an average survival time of 17.06 months (see figure 3b). Stable disease patients survived for 10.6 months and progressive disease patients for 9 months on average (figure 3b). Interestingly, the gender seemed to have an influence on overall survival as the average survival time for women was 15.7 months and 11.1 months for men post SRT (figure 3a). This difference was most apparent within the partial response group, where the average survival time for women was 24.9 months and for men 12.1 months. This difference could neither be explained by the starting size of the lesions nor by an age difference between the groups (figure 3a).

Next, the categorization into 3 responder groups was compared between the two different measurement protocols. As described in the materials and methods sections, both measurements were obtained using Osirix and examples are shown in figure 1c and d. Our results show that the chosen categories were the same for both measurement types in 81.8% of the cases (figure 3c). The remaining 18.2% were grouped differently and made up a total of 10 MRTs (figure 4b). As the 2d measurements are the gold standard, all calculations were performed based on categories obtained from these measurements. In every instance, the wrongly grouped metastases could be explained by either small gadolinium uptake, cystic morphology or small size, which in turn led to wrong volumetric measurements (figure 4a and b). In these cases, the volumetric measurements seemed to be more susceptible to errors and might therefore be less accurate. The problem is that each patient needs to be identified correctly, whereas the 2d measurements only rely on a single measurement in the plane where the lesion is most prominent.

**Conclusion**

We conclude that the results obtained from 2d and 3d measurements are highly comparable and that no benefit from 3d tracking could be observed. Although it is more accurate in identifying small changes in size, the increased time consumption and increased error rate makes it unsuitable for routine analysis. Large scale studies based on automatic algorithms could overcome these hurdles in the future but for now we recommend the use of the RANO−BM criteria in 2d linear measurements for clinical use.

**References**


**Figure 3** Survival times of patients after SRT and misclassification of metastasis

Figure 3a shows the average survival time of patients post SRT separated by gender and response to treatment. The over all survival time is shown in figure 3b. The number and distribution of misclassified metastases are shown in figure 3c.

**Figure 4** Misclassification of metastasis

Examples of metastasis that were wrongly classified are shown in figure 4a and the distribution of misclassified patients is shown in figure 4b (B) It is further separated by percentage of misclassified patients and percentage of the total amount of patients.