Evaluation of superficial dosimetry between treatment planning system and measurement among several breast cancer treatment techniques

Introduction: Superficial dose is one of the important factors in breast treatment for curative and cosmetic outcome. However, it is known that most treatment planning system may not provide adequate and accurate dosimetric information in buildup region. It is also compounded by the calculation grid size, and algorithm used. It is generally accepted that surgical scar should be covered by the prescribed dose to eliminate seeding of malignant cell thus reducing recurrences. Additionally, superficial dose coverage is critically important if tumor has extension close to skin. The data from our institution collected for 111 patients showed that a fraction of patient do not get adequate dose coverage towards skin. Figure 1A, shows frequency distribution of the depth for 95% dose coverage based on Eclipse treatment planning system. It is common knowledge that most commercial treatment planning system cannot accurately calculate dose distribution in the build-up area. The purpose of this study is to investigate the actual superficial dose in breast treatment using various treatment techniques. In this study, we measured the superficial dose using Gafchromic EBT2 film [1] with the help of in-house developed software for curved superficial dosimetry and compared with various techniques (tangential, Field-in field, electronic compensator & IMRT) used for the breast cancer treatment using AAA algorithm.

Phantom design and measurement: We used humanoid acrylic whole body phantom. Four sheets of superflab mimicking breast tissue were put on the phantom’s breast; two sheets of 5 mm thickness and another two sheets of 3 mm thickness. For measurements, EBT2 films were placed between each bolus layer to represent depth in breast. Treatment plans and irradiation were performed using Eclipse treatment planning system and Trilogy linear accelerator (Varian Medical Systems). Before irradiation, gantry was rotated by 20° step and the positions of central axis for each angle were marked on films (figure 1B). The optical density-to-dose calibration curve was created at the same day as of the phantom measurement. The red color channel was extracted from scanned image and then converted to dose. The film density was converted to dose distribution using an in-house software.

Development of in-house software: The in-house software was developed using Visual C++ (Microsoft) for data acquisition. On axial CT image, lines were manually drawn on EBT films (figure 1B). Then the dose profiles on the lines were collected. The positions of the marker on films were mathematically calculated for each gantry angle. Figure 1C shows the algorithm in the software for matching two dose profiles. Both red bars on the upper graph and green bars on the film represent the mark positions on film for each gantry angle. Both the calculated dose profiles and measured dose distributions were separated in segments by these mark positions. Then the calculated segments were stretched to adjust their resolutions to those of the appropriate measured segments using liner interpolation.
Results: For all techniques, the difference between calculated and measured doses were small (approximately <5%) at 6 mm and 11 mm depth from phantom surface. On the other hand, at 3 mm depth, the measured doses for all techniques were larger than calculated dose by 15-30% (Figure 2). Interestingly, the results of tangential technique and IMRT depended on calculation grid size; the calculation with 1x1 mm² grid size showed smaller difference than 2.5x2.5 mm² grid size. However, the grid size did not affect the result of field-in-field and electronic compensator techniques.

Fig. 1; (A) δ: The distance between skin and 95% isodose line; the data for sixty patients. (B) Axial CT image of the phantom. Blue, green, and orange lines represent the EBT2 film positions. Red and yellow crosses represent the positions of isocenter and mark on films for each gantry angles, respectively. (C) Scheme of calculation algorithm in software.

Fig. 2. Superficial dose profile of tangential beams at 3 mm depth (A) and 6 mm depth (B) are shown. Red, blue, and green lines represent film dosimetry, calculation, and percent difference, respectively. Solid and dot lines stand for calculation with 2.5 mm and 1 mm grid size, respectively.

References: