EPID picket fence test-based MLC QA: Integration methods with partially removing beam radiation scattering between strips

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INTRODUCTION

Click The MLC enables the linac to sculpt the dose to the tumor target volume in three dimensions, resulting in a homogeneous and conformal dose distribution within the tumor target volume with minimal dose to the organs at risk and a steep dose drop-off around the tumor edges. The dosimetric benefit from MLC is largely dependent on the positioning accuracy of the leaves.

Although current MLC QA algorithms demonstrated high positional accuracy, the majority relied on fixed PF strip patterns. Unplanned adjustments to the strip count or spacing could compromise their computational accuracy, which was a limitation particularly evident in commercial software.

The full width at half maximum (FWHM) method remained a classical edge detection algorithm for MLC QA. However, it was susceptible to fluctuations in pixel values. Sumida et al.[1] noted that performing the PF test alone may be insufficient for evaluating leaf positioning accuracy and called for the ongoing implementation of non-gap test. The stakitt test developed by Barnes et al.[2] overcame the inherent limitations of the PF test for MLC QA. However, the analysis algorithm was implemented and validated using a strip width of 20 mm.

A series of PF tests was designed in this study to systematically evaluate and partially mitigate inter-strip beam radiation scatter. On this basis, the more robust MLC QA algorithms were developed as an improvement over the classical FWHM method

REFERENCES

1. Sumida, I., Yamaguchi, H., Kizaki, H., Koizumi, M., Ogata, T., Takahashi, Y.&Yoshioka, Y., 2012. Quality assurance of MLC leaf position accuracy and relative dose effect at the MLC abutment region using an electronic portal imaging device. J. Radiat. Res. (Tokyo) 53, 798–806.
2. Barnes, M., Standen, T., Blackmore, R.&Greer, P., 2025. Evaluation of an improved picket fence style test for routine MLC positional QA. J Appl Clin Med Phys 26, e14567

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METHODS

A series of electronic portal imaging device (EPID) PF test patterns were designed by varying strip width (range: 7–13 mm, increment: 1 mm) and spacing (range: 10–20 mm, increment: 2 mm) to quantify the influence of strip beam radiation scatter on three algorithmic parameters (full width at half maximum, peak height, and peak area). This influence was partially compensated by establishing a scatter library. Subsequently, three MLC QA algorithms (FWHM-based, peak height-based, and peak area-based) were developed using the respective parameters derived from log files. To enhance accuracy and robustness, two integrated approaches a voting-based method and a linear fitting-based method were proposed by combining the three algorithms. Additionally, the effects of different data processing strategies and strip spacing on the positional accuracy of the developed algorithms were analyzed to identify the optimal algorithm development paradigm.

RESULTS

An increase in both FWHM and peak area was observed for different-width stripes at all positions in the PF test image as the stripe spacing increased, while peak height exhibited the opposite trend **(Figure 1)**. The FWHM and peak height gradually decreased from the central strip to the two side strips of the PF test images at a fixed strip spacing. Except for the edge stripes, the peak area of the remaining stripes remained nearly unchanged **(Figure 2)**. The highest algorithmic position accuracy was achieved by performing independent algorithm development for the algorithm parameter for each opposite leaf in every strip **(Figure 3)**. The overall absolute position error of the algorithms was relatively constant (0.155±0.168 mm) when the strip spacing was not less than 16 mm **(Figure 4),** and the absolute position errors of each algorithm was 0.294±0.213 mm (peak height method), 0.100±0.086 mm (peak area method), 0.071±0.054 mm (FWHM method), 0.057±0.062 mm (VIM), and 0.036±0.528 mm (FIM) **(Figure 5).**

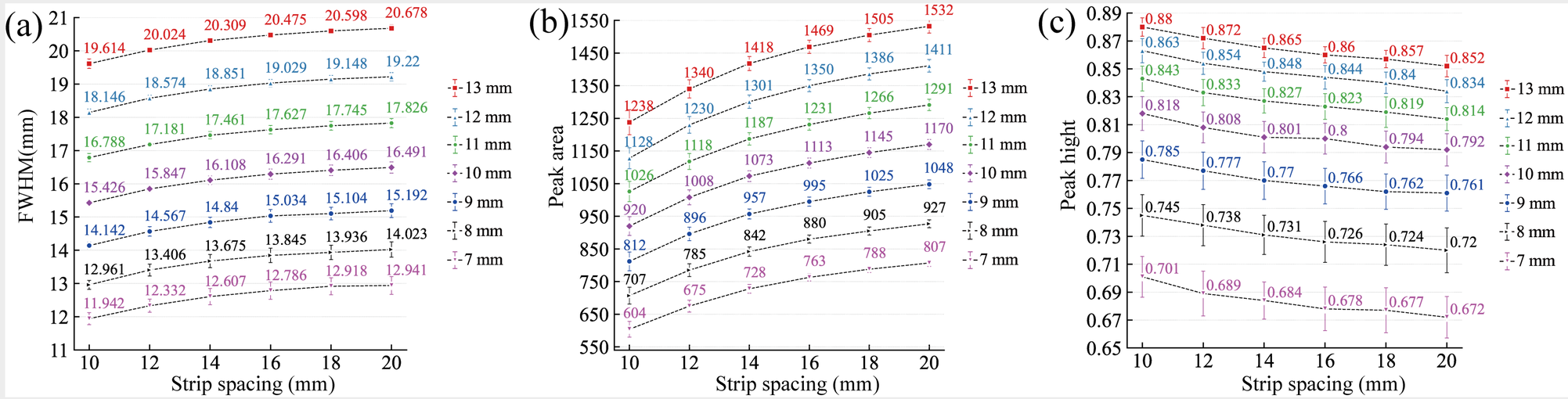

Figure 1. The variation in algorithmic parameters of different width strips with increasing strip spacing: FWHM(a), peak area(b), peak height(c).

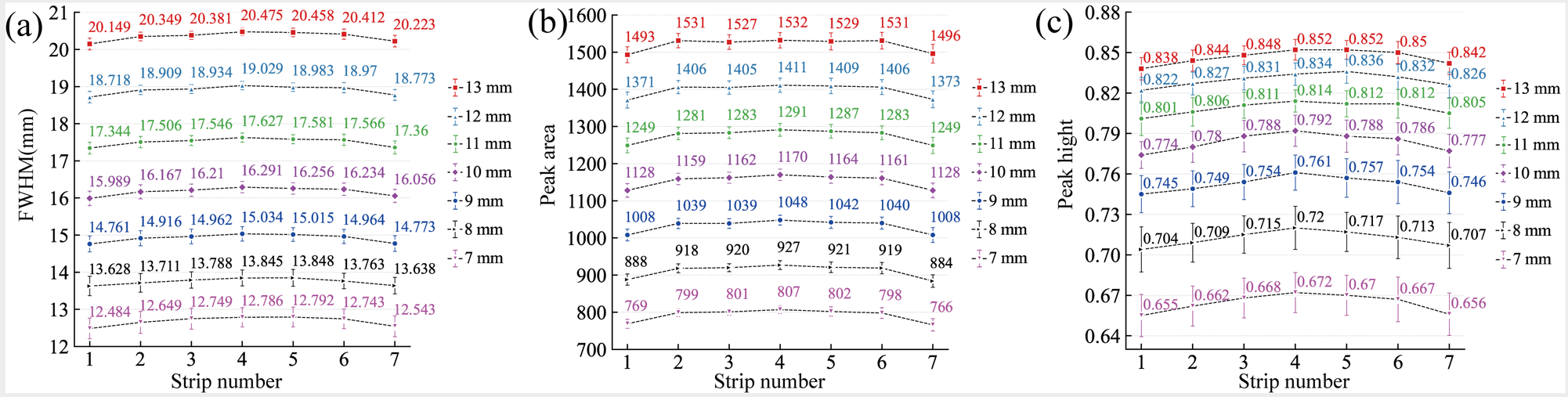

Figure 2. The variation in algorithmic parameters of different widths changes depending on the position of the strips: FWHM(a), peak area(b), peak height(c).

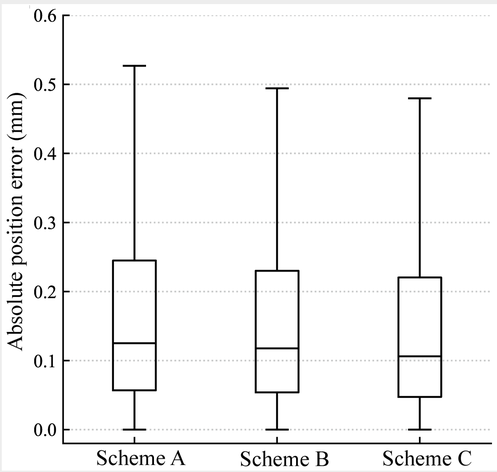

Figure 3. The overall position accuracy of the algorithms for different data processing schemes

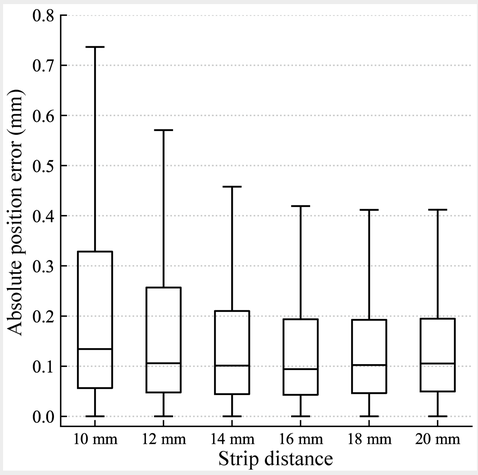

Figure 4. The overall position accuracy of the algorithms for different strips spacings

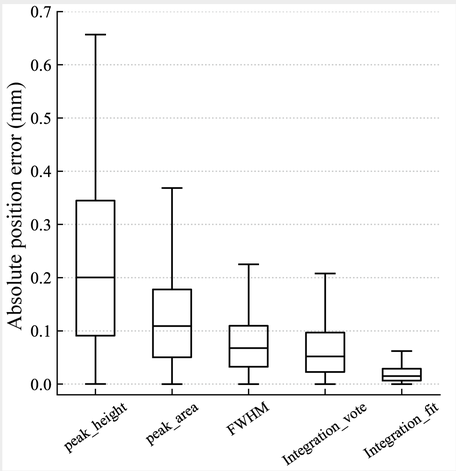

Figure 5. The position accuracy of all algorithms

CONCLUSIONS

1. This study proposed two effective and robust MLC QA integration methods that can reduce partial radiation scattering.
2. When the strip spacing exceeds a certain threshold, the algorithm's positional accuracy is almost unaffected by the strip position or spacing.

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