

Star-shot analysis of radiation isocenter wobble: Quality control of quality control tools

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Purpose

To devise a secondary cross-check for the software used in the quality control (QC) of the isocenter wobble during the collimator, couch and gantry rotation.

Materials and methods

Monthly QC of the radiation isocenter wobble is performed with 3 slit-like fields spaced 120° apart (Fig. 1), exposing cassettes with phosphor imaging plates, which are scanned using Kodak ACR-2000 tabletop computed radiography system. The ensuing DICOM images were first analyzed with PipsPro 4.4 (Standard Imaging, Middleton, WI, USA) and later re-analyzed with Pylinac 2.0.1 (James Kerns, <https://github.com/jrkerns/pylinac>) starshot module. The diameter of the incircle which touches the projections at the point of intersection is taken as an estimate of the isocenter wobble.

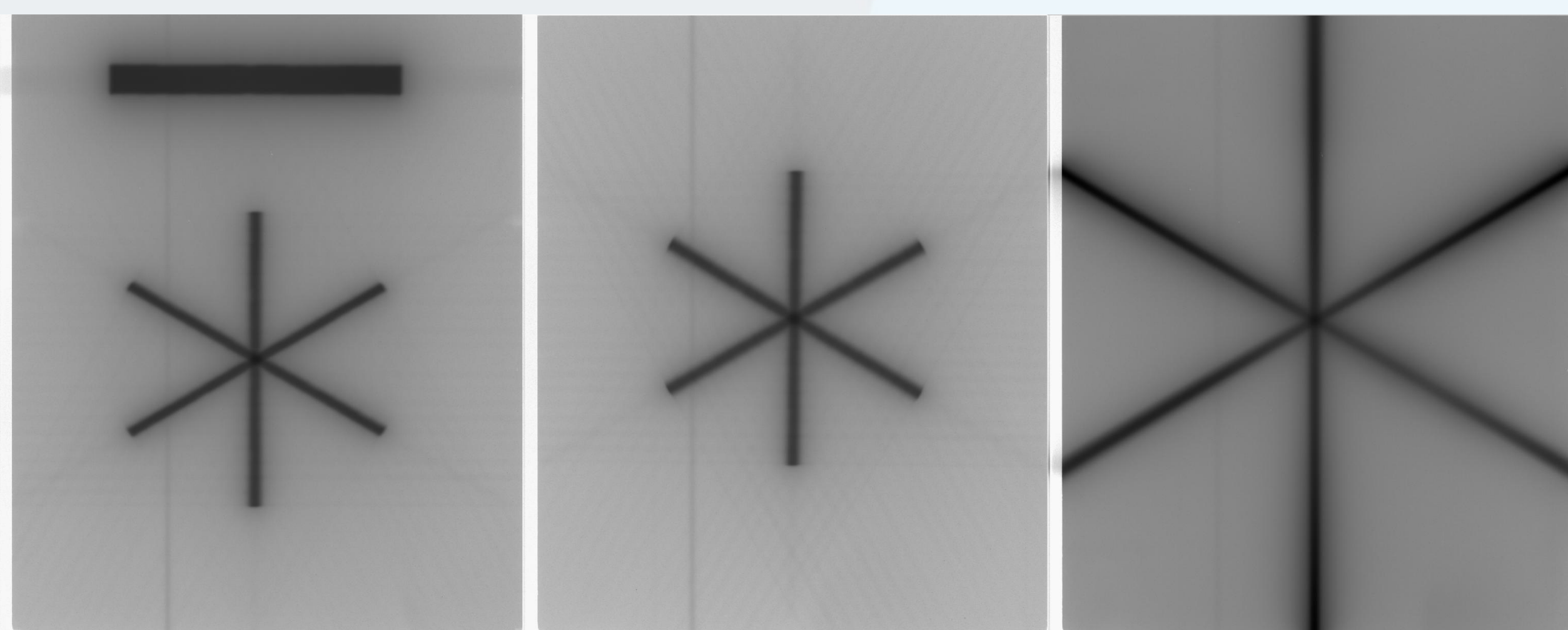


Figure 1: Images of slit field during the rotation of the collimator (left), couch (middle) and gantry (right). The collimator rotation image is exposed with an extra off-center slit to distinguish it from the couch rotation image.

We evaluated the accumulated set of images acquired during monthly QA for 7 different linacs at our clinic between late 2014 and early 2017. In addition to the set of real machine data, we also wrote a Python script to produce a set of synthetic images, comprised of three slightly off-center intersecting lines, with the radius of the incircle set to 0, 0.1, 0.2, 0.3, 0.5, 0.7, 1.0, 1.5, and 2.0 mm (Fig. 2).



Figure 2: A synthetic DICOM image of lines intersecting at 120° and slightly off-axis, forming a triangle with a defined incircle radius.

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Results

We have grouped the results into three groups, for low-energy Varian Clinacs (3 machines), dual energy Varian Clinacs (2), and Elekta Synergy platform machines (2). Figure 3 shows the results for the 3 low energy linacs (treatment machines #1, #2 and #5 at our clinic). The results for other two groups are qualitatively similar.

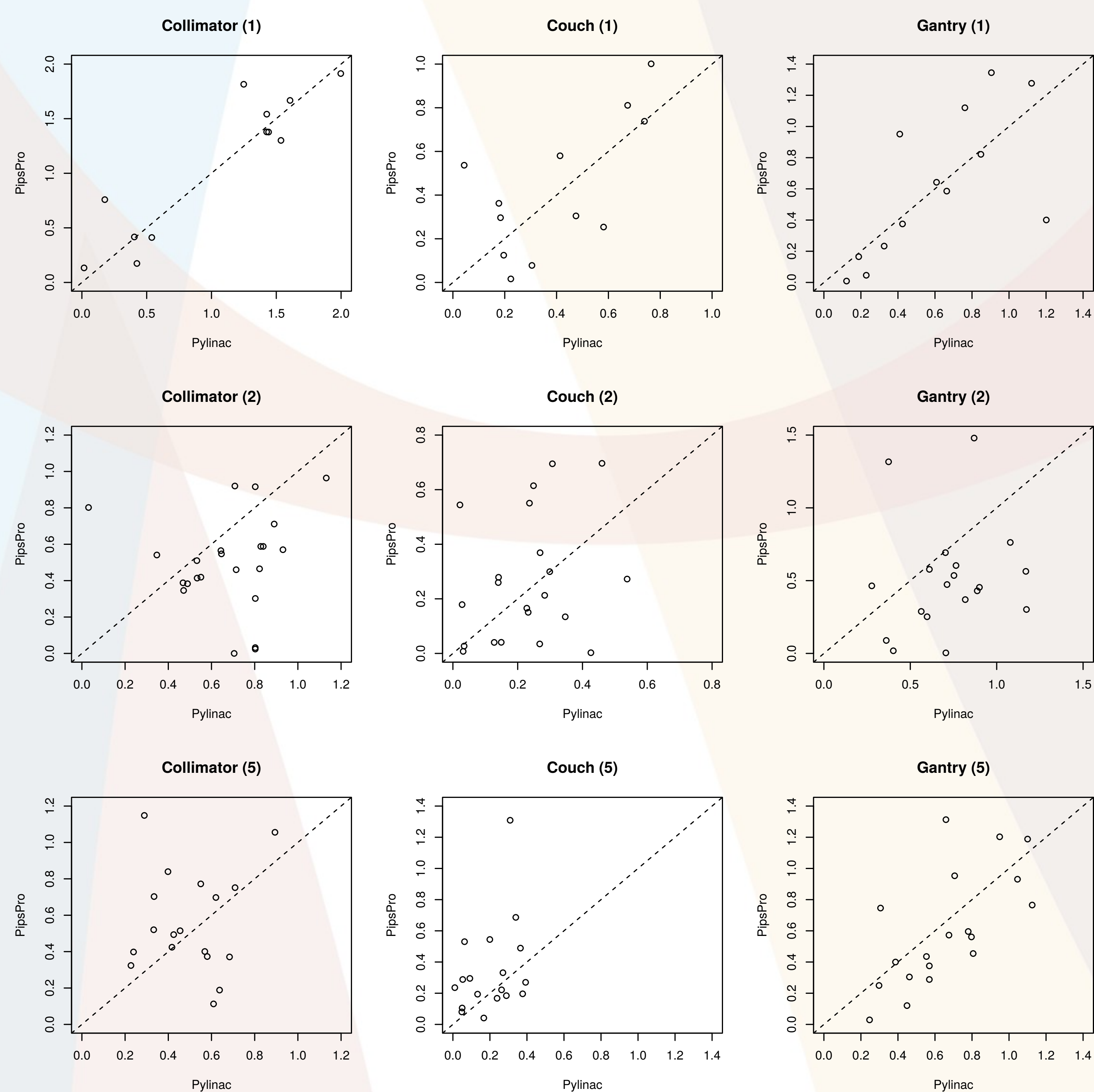


Figure 3: Comparison of the isocenter wobble determined with two different programs. A point in the scatter plot corresponds to a DICOM image being analysed, its x-coordinate corresponds to the incircle diameter obtained by Pylinac, and its y-coordinate to the incircle diameter obtained by PipsPro.

Overall, the results based on images obtained on treatment machines show less correspondence than we initially expected. Fig. 4 shows how well both programs reproduce the incircle radius from synthetic images.

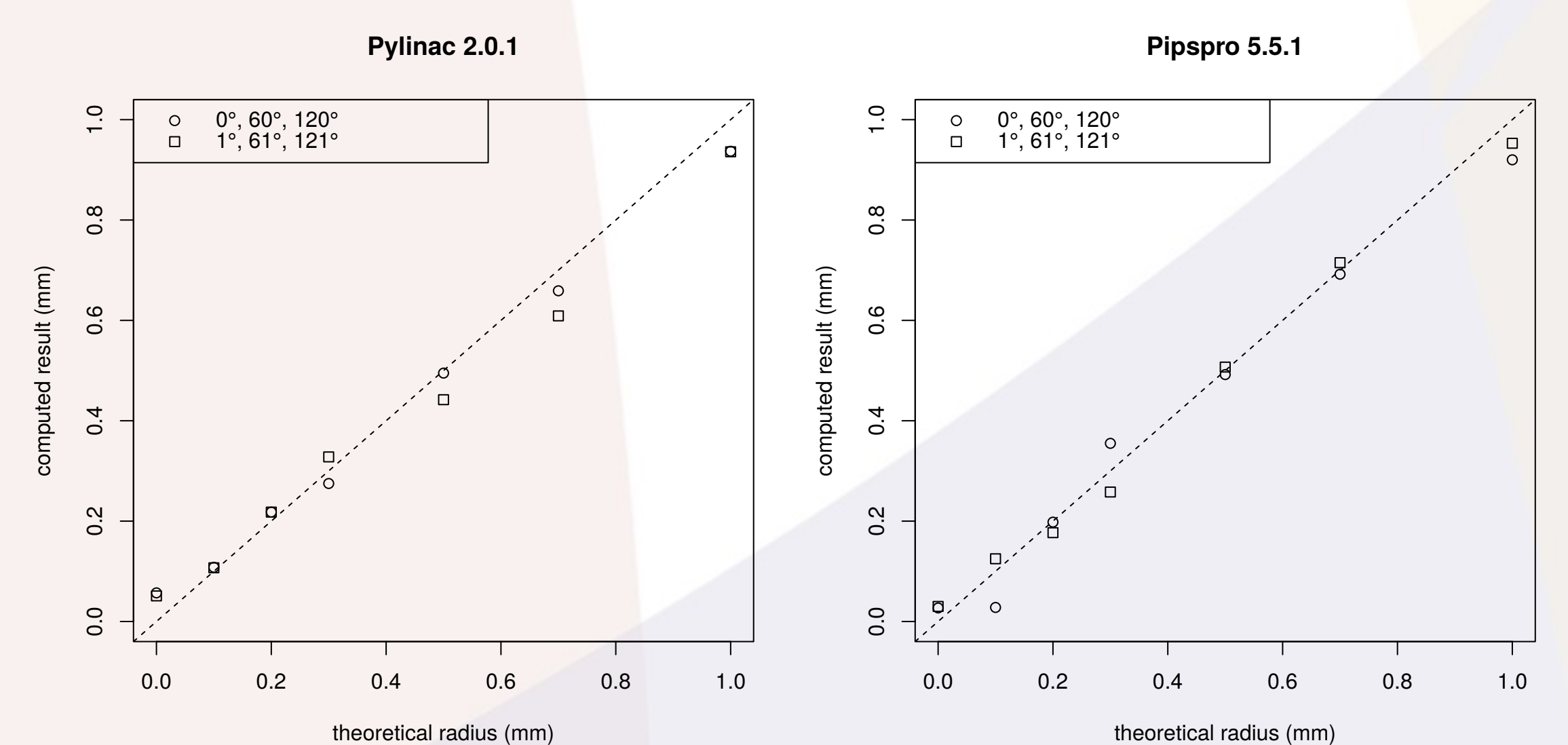


Figure 4: Incircle radius computed with both programs on a set of synthetic DICOM images.

Conclusions

Both programs satisfactorily reproduce the incircle of synthetic images; real machine data requires further investigation.