

## Background

Patient-specific quality assurance measurements are time consuming and Gamma pass/fail criteria are often picked based on typical criteria used for IMRT QA measurements in the past. The questions needs to be asked if with these criteria QA plans could still show clinically significant deviations from the treatment plan calculated and how we should be doing QA for treatment delivery of complex treatment plans. In our study DICOM files of clinical Rapidarc plans were modified with in-house developed software to mimic leaf alignment errors and gravitation shifts. The Octavius 2D-ARRAY (PTW-Freiburg) and the Delta4 device (Scandidos) were used to investigate the effect of the simulated errors on the passing rate of quality assurance results. The manipulated Rapidarc plans were recalculated on patient CT scans in Eclipse.

## Methods and Materials

Three different types of errors were simulated and applied to five prostate (two arcs), three 2-arc head and neck cases and three 3-arc head and neck cases. The MLC modifications were: (1) both MLC banks are opened by 0.25mm, 0.50mm and 1.00mm in opposing directions resulting in larger fields, (2) both MLC banks are closed by 0.10mm, 0.25mm and 0.50mm, (3) both MLC banks are shifted in the same direction for lateral gantry angles to simulate effects of gravitational forces onto the leaves by 1mm, 2mm and 3mm, (4) 25%, 50% 70% and 100% of all active leaves are shifted by 3mm as in (3). QA evaluations were performed according to a gamma-index criterion of 3mm and 3% as well as 2mm and 2%.

MLC modification	1. error	2. error	3. error
<b>Type 1 (open MLC leaf banks)</b>	0.25mm	0.50mm	1.00mm
<b>Type 2 (close MLC leaf banks)</b>	0.10mm	0.25mm	0.5mm
<b>Type 3 (gravitational shift)</b>	1mm	2mm	3mm

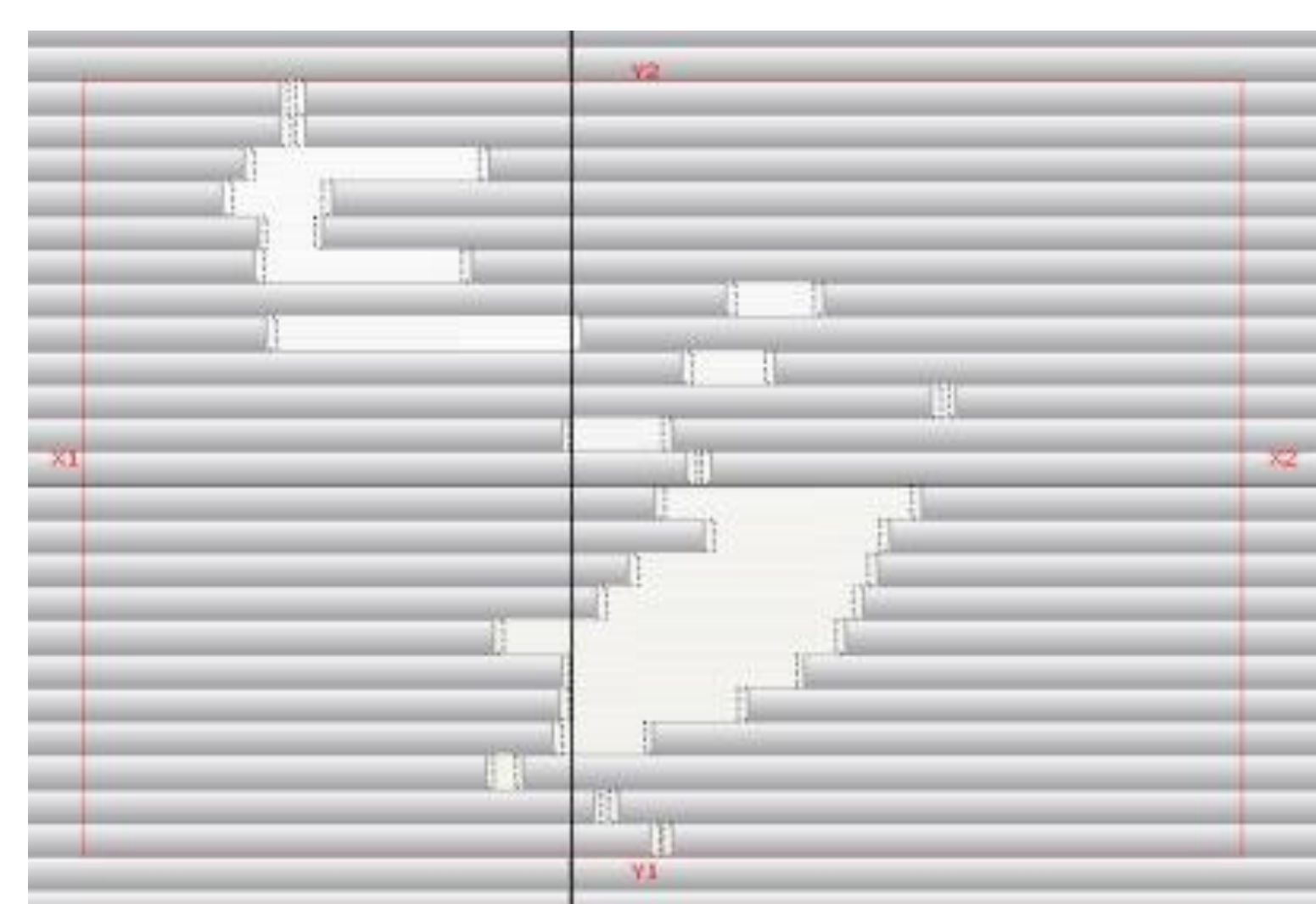


Fig. 1: Screenshot of software with type 1 modification. Original leaf position as dashed lines

## Results

All unmodified plans and the majority of the plans with the smallest modification pass the gamma-index criterion of 2%/2mm with >90%. After that the passing rate drops below 90%. For the largest modifications passing rates were typically below 85%. The Delta4 is generally more sensitive and the passing rate for modified plans drops below 90% earlier and more drastically. With the standard criteria (3mm, 3%) even the largest modifications would satisfy a >90% passing rate.

## Conclusion

A stricter gamma-index (2mm, 2%) is necessary in order to detect MLC positional errors and a passing rate of >90% should be expected. Clinical pass/fail criteria need to be developed.

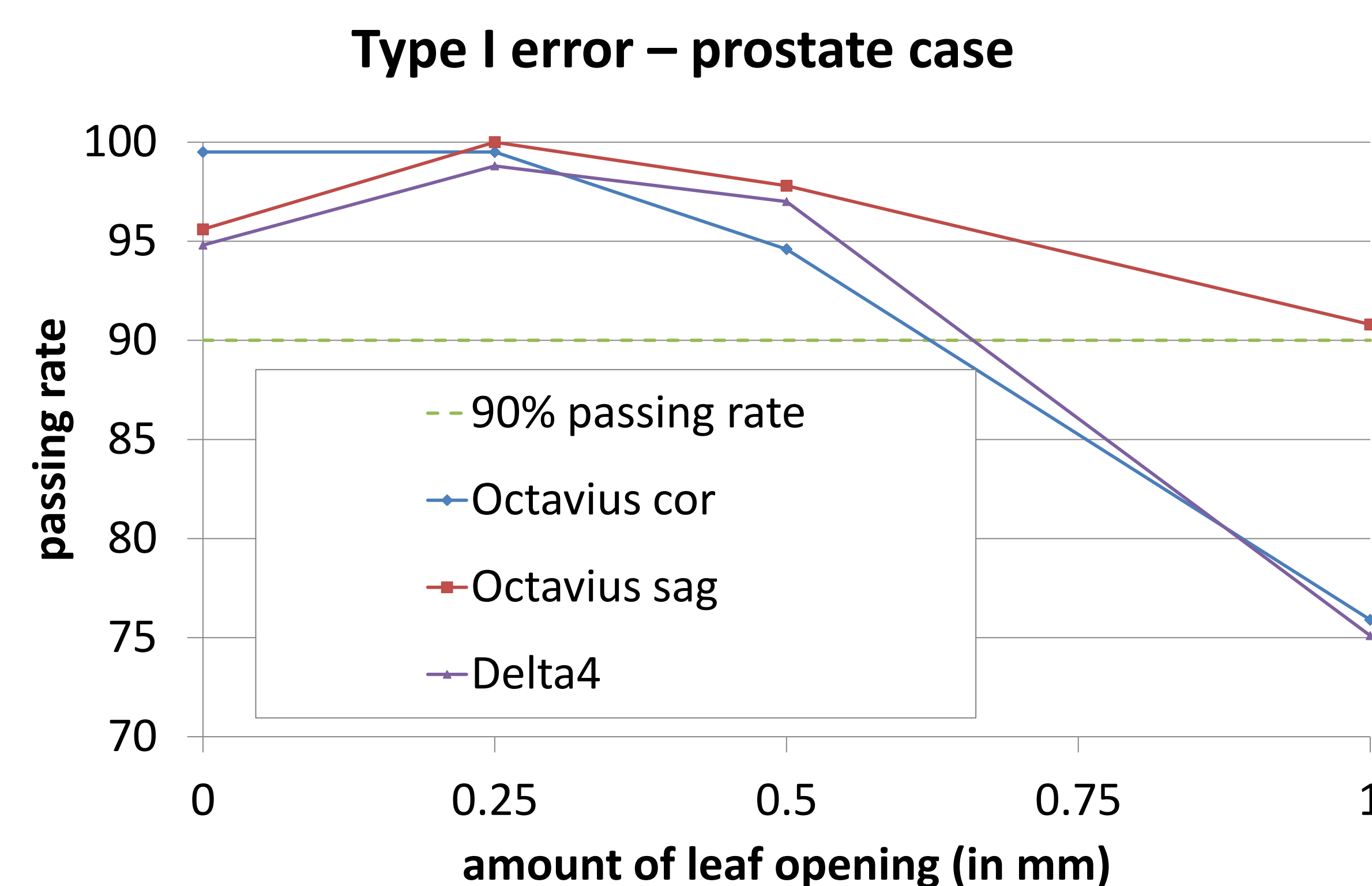


Figure 2: 2%/2mm Gamma passing rates changed with an increase of the magnitude of a type 1 error for a prostate case.

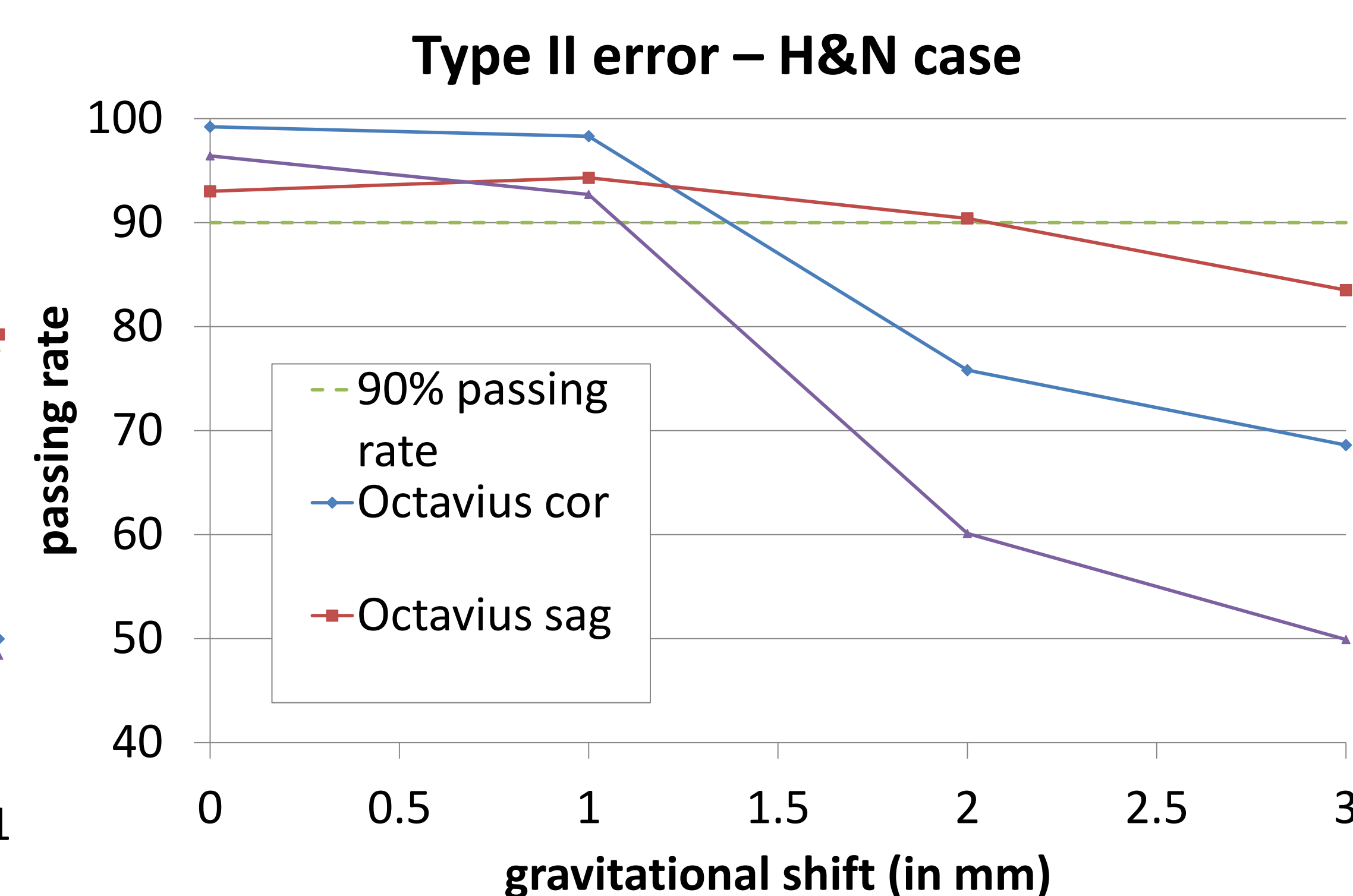


Figure 3: 2%/2mm Gamma passing rates changed with an increase of the magnitude of a type 2 error for a prostate case.

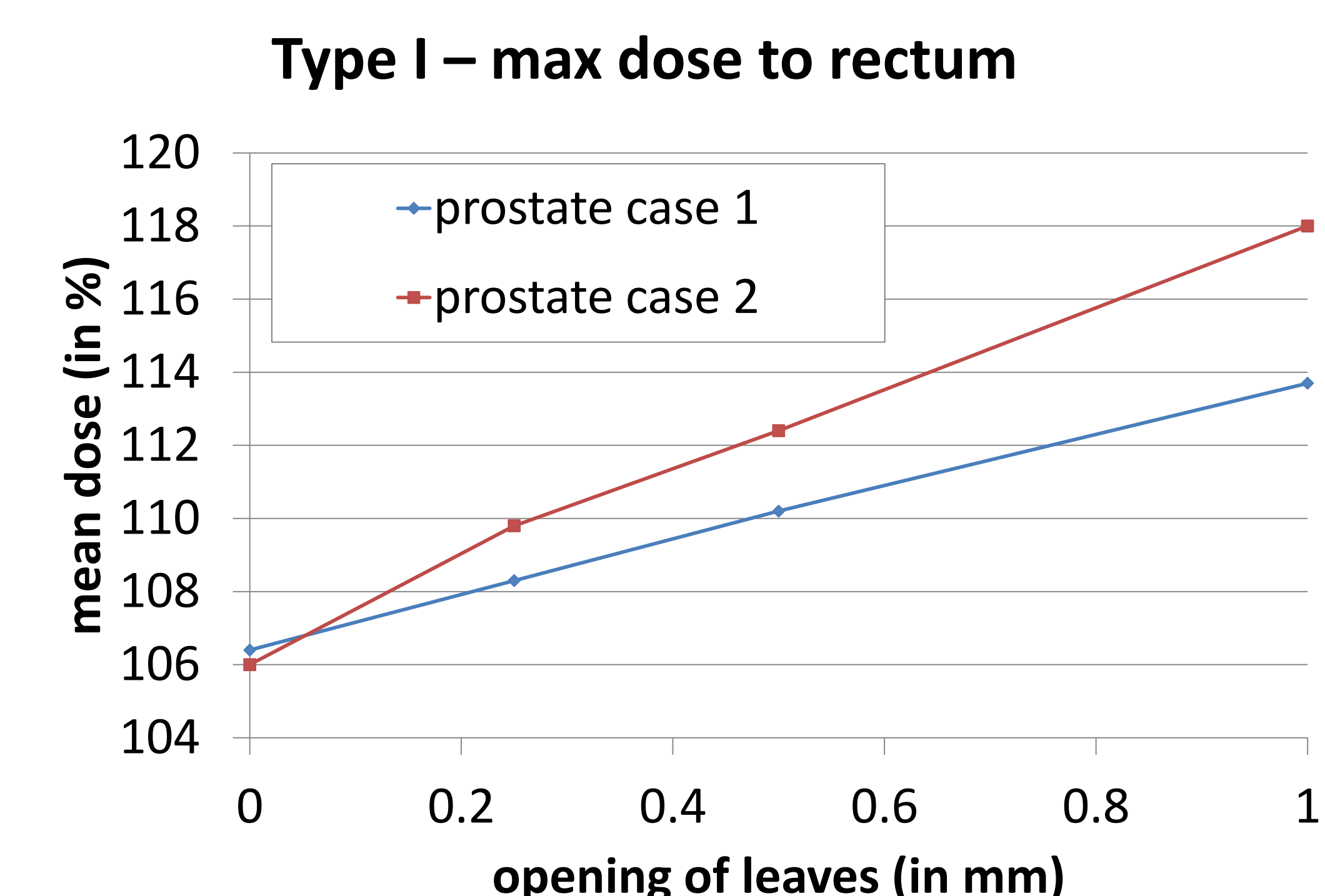
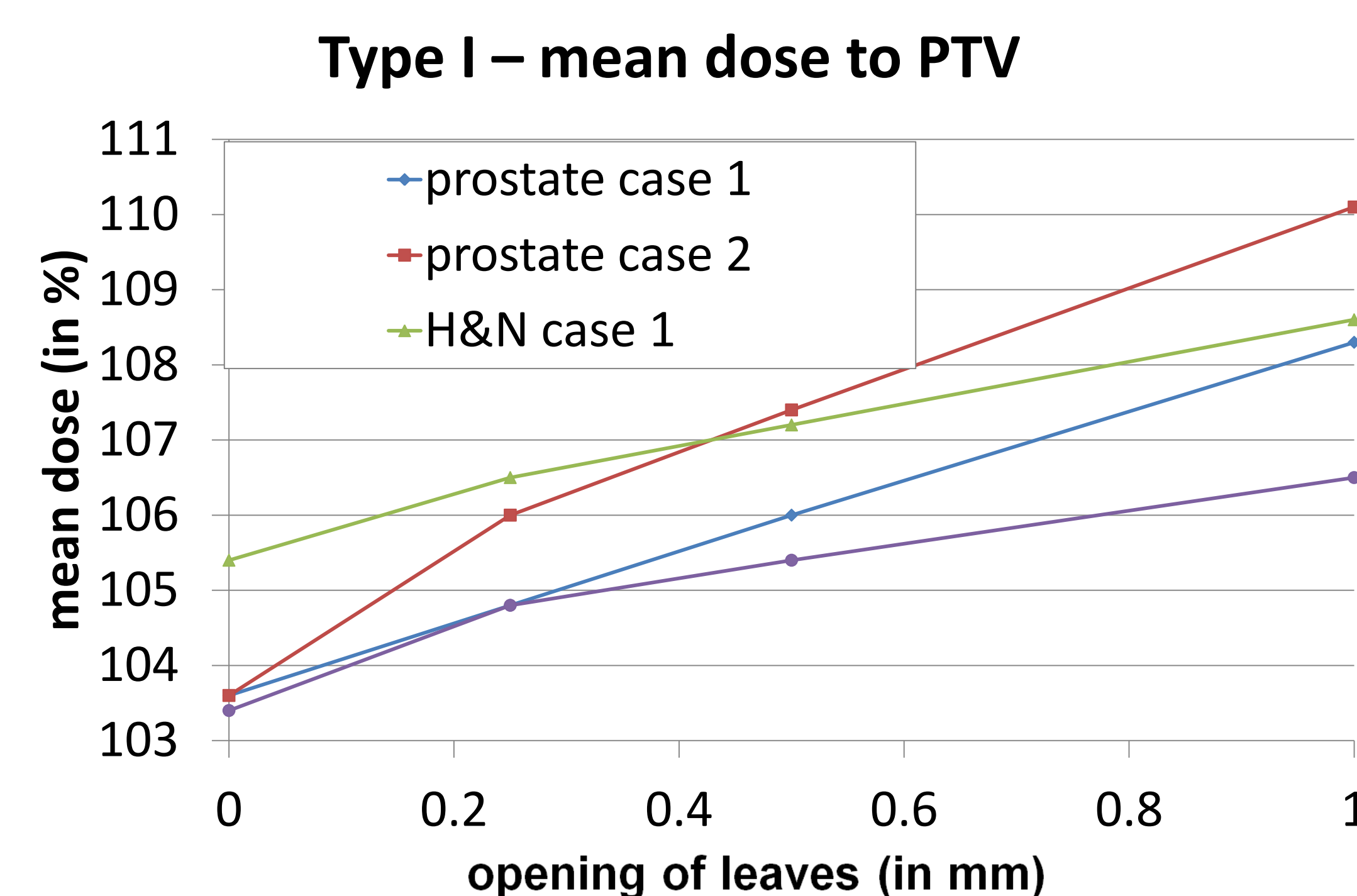


Figure 4: The two graphs show the change in mean dose to the PTV (left) and maximum dose to the rectum (right) for an increase of the magnitude of a type 1 error

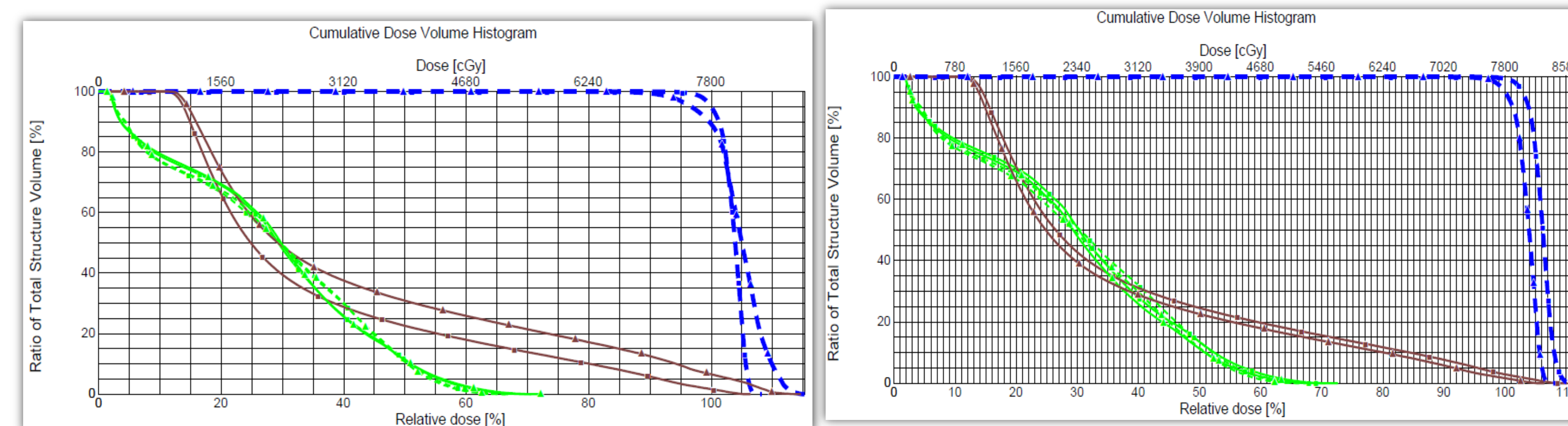


Fig. 5: Two DVHs of prostate cases comparing the original plan (Δ) and (a) type 1 modified plan with a 0.50mm MLC leaf bank opening (□) and (b) type 3 modified plan with a 2mm gravitational shift. Displayed are the curves for the PTV (blue), the rectum (brown) and the left and right femoral heads (green).