

# Comparison of different test platforms for isocenters analysis at stereotaxic techniques perspective

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## INTRODUCTION

A comprehensive quality assurance program, evaluating the isocenter size from the perspective of gantry, collimator and couch must be established at Linear accelerators that perform stereotatic radiotherapy techniques.

The isocenter average should be  $\leq 0,75$  mm and  $\leq 1$  mm at maximum isocenter [1, 2]. Based on this limits, it is possible to establish three action levels: inspection, programmed action and immediate action (if it exceeds 1 mm).

This works evaluates three commercially available tests: Machine Performance Check - MPC (*enhanced couch test*), Integrated Conical Collimator Verification and Interlock (ICVI), both from Varian Medical System, and Multimet, from Sun Nuclear. The reference value test used is the *isolock*, wich is performed by the linear accelerator service engineer team.

## MATERIALS / METHODOLOGY

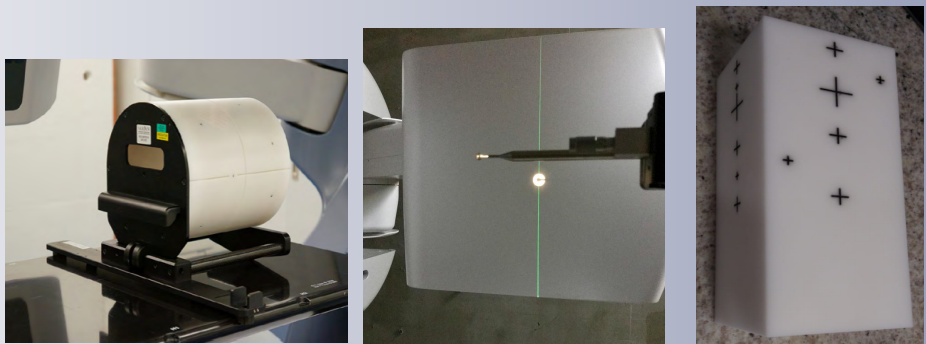


Figure 1.a Isocal (MPC) Figure 1.b ICVI Figure 1.c Multimet

The **Figure 1.a** shows the Varian isocal phantom, used for Machine Performance test. The isocal is a cylinder with 16 tungsten carbide spheres, each one with 4 mm in diameter. The isocenter size is calculated from the automated combination of high MV and KV high resolution images, acquired for diferent gantry, collimator and couch position.[3]

The **Figura 1.b** shows the Varian Conical Collimator Verification and Interlock system (ICVI) test, in wich a set comprised of a tungsten radiopaque sphere, aligned through a micrometer coupled at the couch. The radiopaque sphere is 1 mm smaller than the 7,5 mm cone, and it is positioned using this cone. The automated analysis is based on deviation of concentricity between the edges of these spheres in each acquired image, varying positions of gantry, collimator and couch.

The **Figura 1.c** shows the Sun Nuclear Multimet-WL QA. This phantom has dimensions of 8,5 x 8,5 x 12,75 cm<sup>3</sup>, rectangular, with 06 tungsten carbide spheres f 5 ± 0,25 mm. Each sphere has a well-defined position, such the sphere S2 represents the isocenter, and the others (S0, S1, S3, S4 e S5) represent targets displaced from the isocenter. Ten images are acquired and analyzed by the software with combinations of gantry, collimator and couch, providing the isocenter calcauted at each position and for each sphere.

The measurements were performed on the TrueBeam STX linear accelerator (AL), at Real Hospital Português, aligning the respective phantoms according to the manual suggested by each manufacturer, as shown in **Figure 2.a, 2.b** and **2.c**, respectively for the Isocal, ICVI and Multimet.

At Multimet, the software analysis provides the phantom alignment (offset), showing the user adjustments that can be applied on the table in order to obtain the best possible setup. In this way, images were acquired based on the alignment through the crosshair (pre images) and also after correction (post image) of the offset.

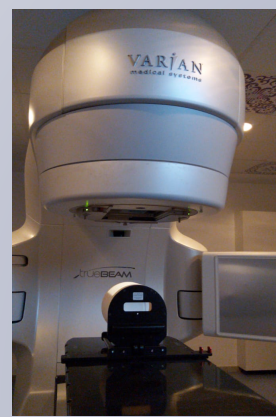


Figure 2.a Isocal (MPC)

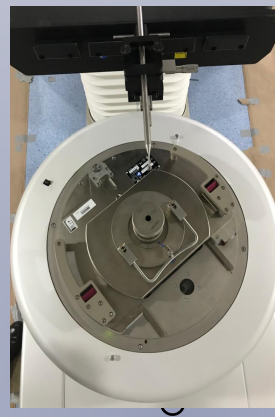


Figure 2.b ICVI

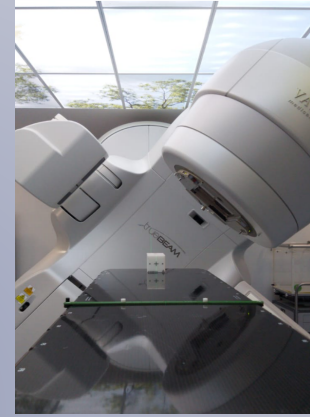
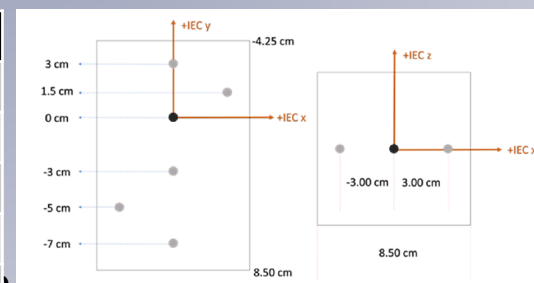


Figure 2.c Multimet

Table 1. Coordinates (x,y,z) of each sphere relative to the isocenter (S2)

ESFERA	X (mm)	Y (mm)	Z (mm)
S0	0	30	0
S1	30	15	0
S2	0	0	0
S3	0	-30	0
S4	-30	-50	0
S5	0	-70	0



**Figure 2.d** Multimet sphere position diagram. The diagram shows the coordinates of each sphere relative to the isocenter (S2). The spheres are positioned at various distances from the isocenter, allowing for the simulation of multiple metastasis radiosurgery treated with a single isocenter. This test allowed to verify the necessary margin as the distance with the isocenter increases.

## REFERENCES

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## RESULTS AND ANALYSIS

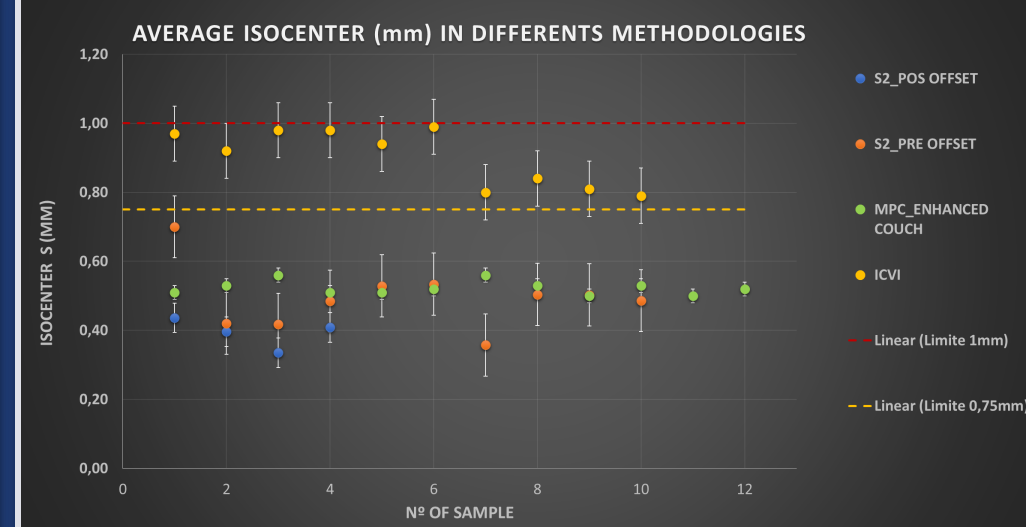


Figure 4. Analysis of the average values of the isocenter found for the Multimet (S2 pre ad post offset corection), ICVI and MPC (enhanced couch) using tolerance limits of 0.75 mm and 1 mm

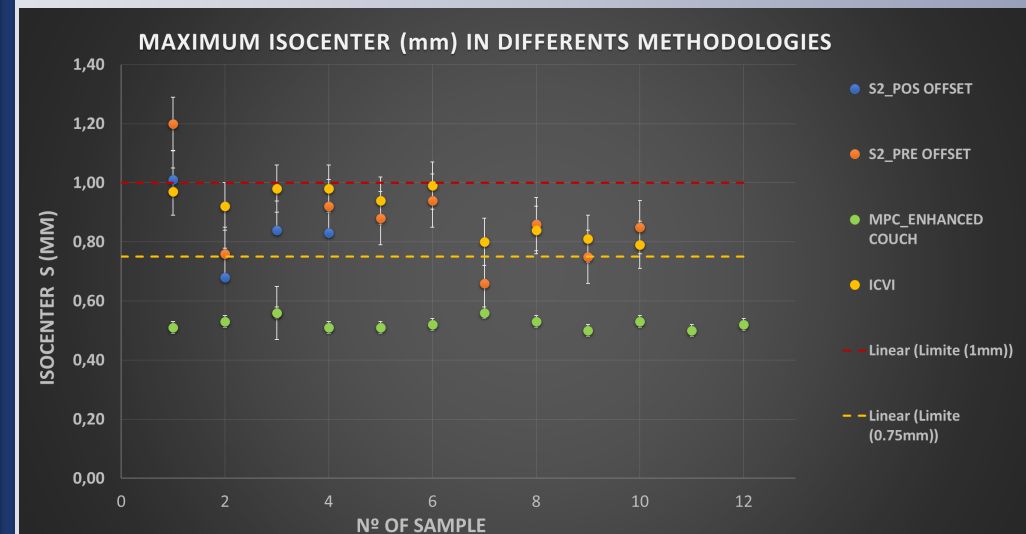


Figure 5. Analysis of the maximum values of the isocenter found for the Multimet (S2 pre ad post offset corection), ICVI and MPC (enhanced couch) using tolerance limits of 0.75 mm and 1 mm

For the MPC and ICVI, the values presented by the analysis software reports were considered as the size of the isocenter measured at this work, being the same in both graphs.

**Figure 4** shows the isocenter size, with average isocenter values for the Multimet, wich the exception of the ICVI, all of them were below the thresholds. However, when evaluating the isocenter size with maximum values for Multimet, we verified in **Figure 5** that Multimet data followed the ICVI behavior, where both indicated programmed action levels (values between 0,75 mm and 1 mm). The AL manufacturer was contacted and more specific tests for the isocenter analysis (isolock) were carried out by the Service team, resulting in an isocenter size of 0,84 mm. This value is acceptable for radiosurgery, but with the possibility of corrective actions to bring the isocenter closer to the equipment's acceptance value (0,54 mm) and below the inspection limit.

The reference values test obtained with the isolock, showed that both ICVI and Multimet can be used to assess the isocenter over the time. More specifically, for the Multimet, both the pre-correction and post-correction offset tests can be used, since the maximum values are evaluated.

The ICVI test has the disadvantage that is difficult to perform it daily, since its positioning is more delicate and time consuming.

The advantage of the Multimet test is that if performed without offset correction, it can be performed daily, taking na average of 15 minutes (alignment and image acquisition) and its result for the maximum values of the isocenter corroborate with the reference values.

Within the quality assurance program it can be performed daily, analyzing images with simple alignment by the cross hair (pre-correction) and when identifying values that refer to some action level, perform measurements with offset crrection in order to obtain a more accurate result.

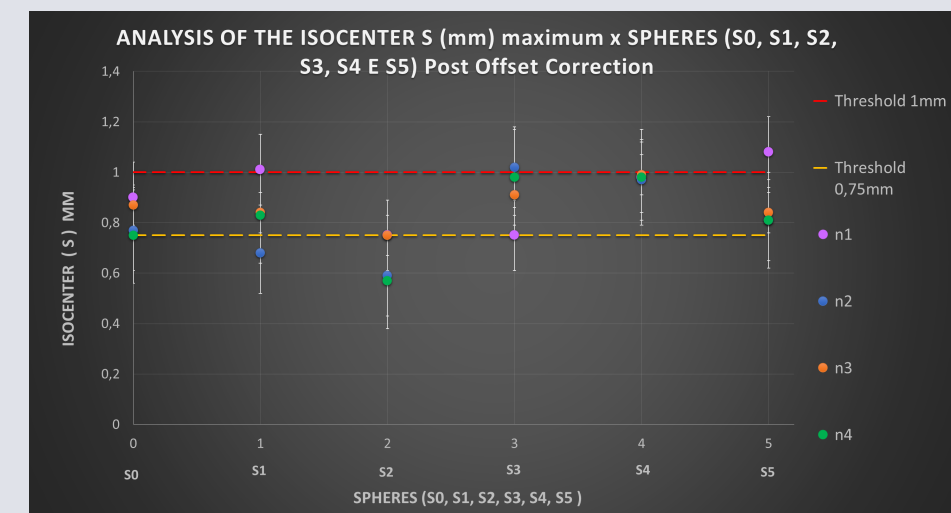


Figura 6. Analysis of the maximum isocenter values of the calculated for the Multimet, with crosshair alignment and with offset correction, as a function of the S0, S, S2, S3, S4 and S5 spheres, using 0,75mm tolerance limits and 1mm.

Through **Figure 6**, the isocenter (with application of offset correction) for each sphere was analyzed. The S5 sphere, with the largest deviation (1,08 mm) is also being 7 cm from the isocenter. The result corroborates the margin already practiced in the Service. It is expected that the results will improve in the reevaluation after the correction of the linear accelerator isocenter, and it should be below the level of investigation.

In the case of MPC, the results don't invalidate its use. It is necessary to better evaluate the sensitivity and precision of the test in the various positions of the image collected, as well the method wich it calculates the isocenter presented in its report: a next step at this work.

## CONCLUSION

Both ICVI and Multimet (when analyzed for the maximum deviatons from the isocenter) showed results comparable to the reference, given by the isolock, a specific test from the manufacturer of the linear accelerator to evaluate the isocenter. The Multimet test had the advantage of being able to be performed daily, using images without offset correction. The answer can be used to assess the isocenter over time as a complementary test, integrating the service quality assurance program.

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