Dosimetric comparison of dose calculations accuracy based on standard and extended CT conversion curve for metallic ports in temporary tissue expanders

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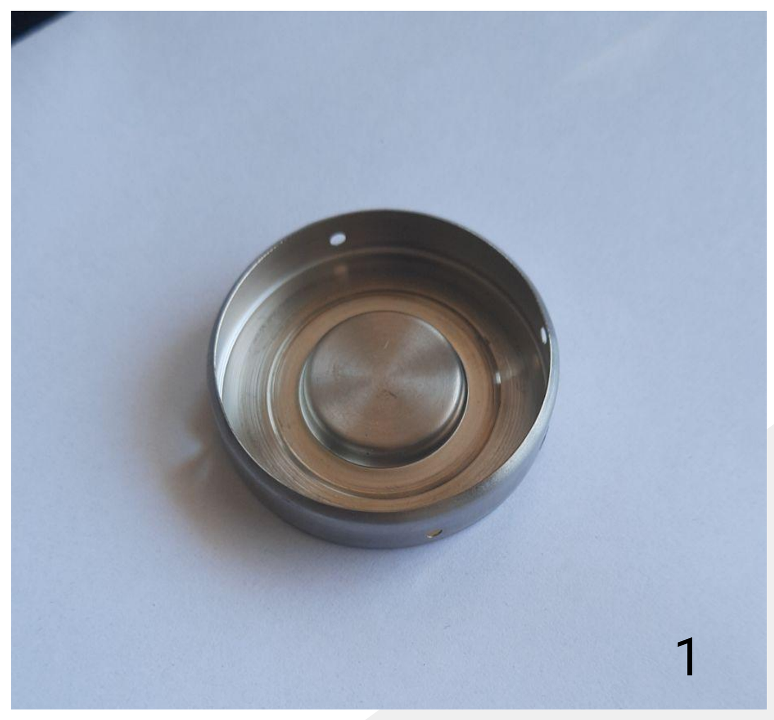
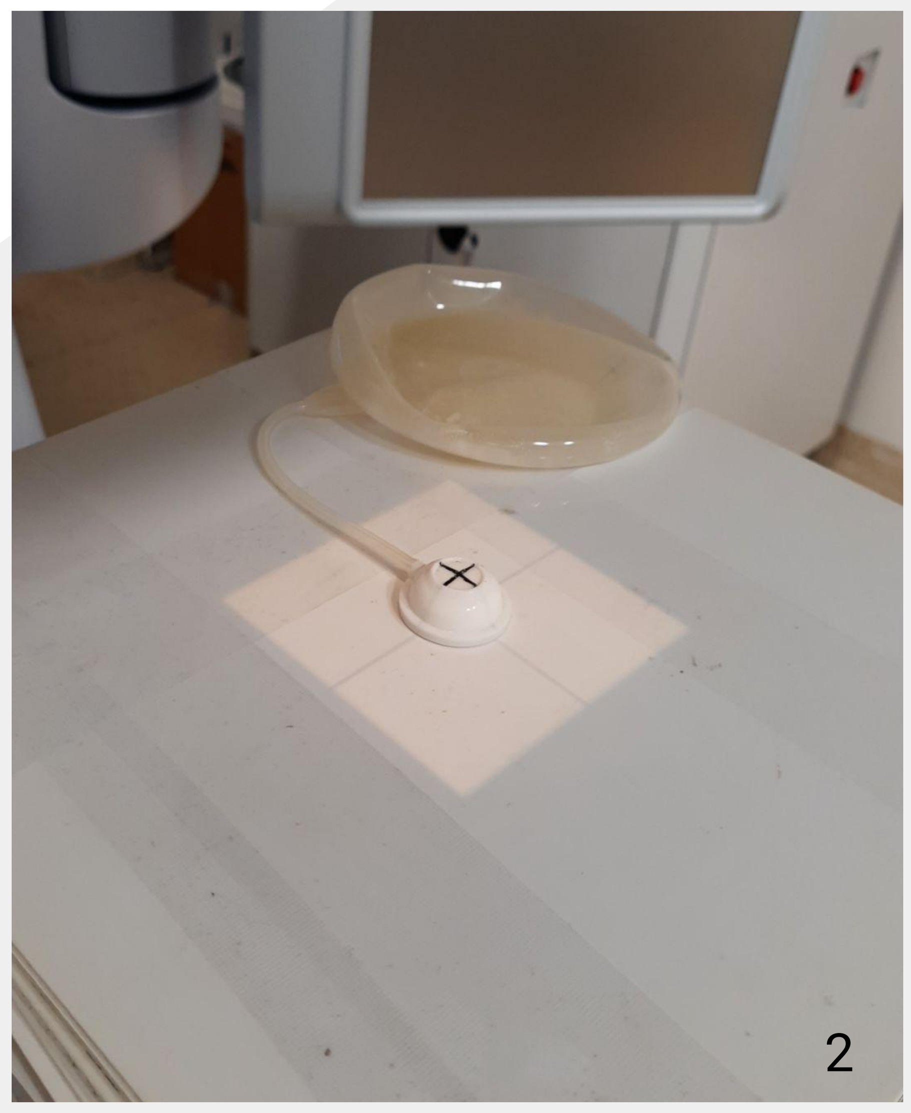
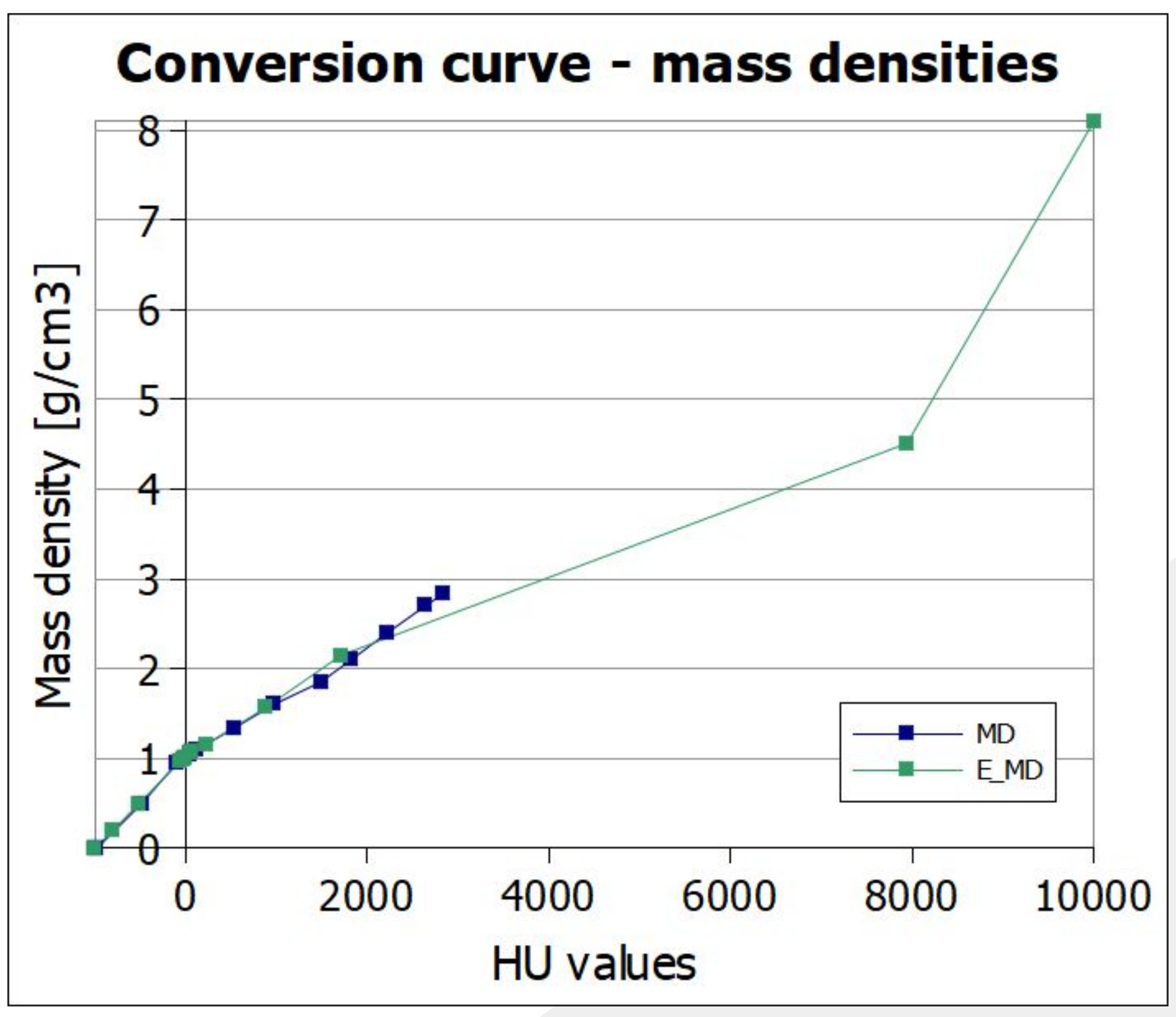
Aim Temporary tissue expanders (TTEs) with a metallic port are currently a wildly used option for mastectomy patients. The magnetic properties of the port allow it to be localised by an external magnet, making it possible to fill the expander with saline injections. However, artefacts in CT and treatment planning systems (TPS) calculation inaccuracy for high-density materials are likely to contribute to discrepancies in dose distribution.

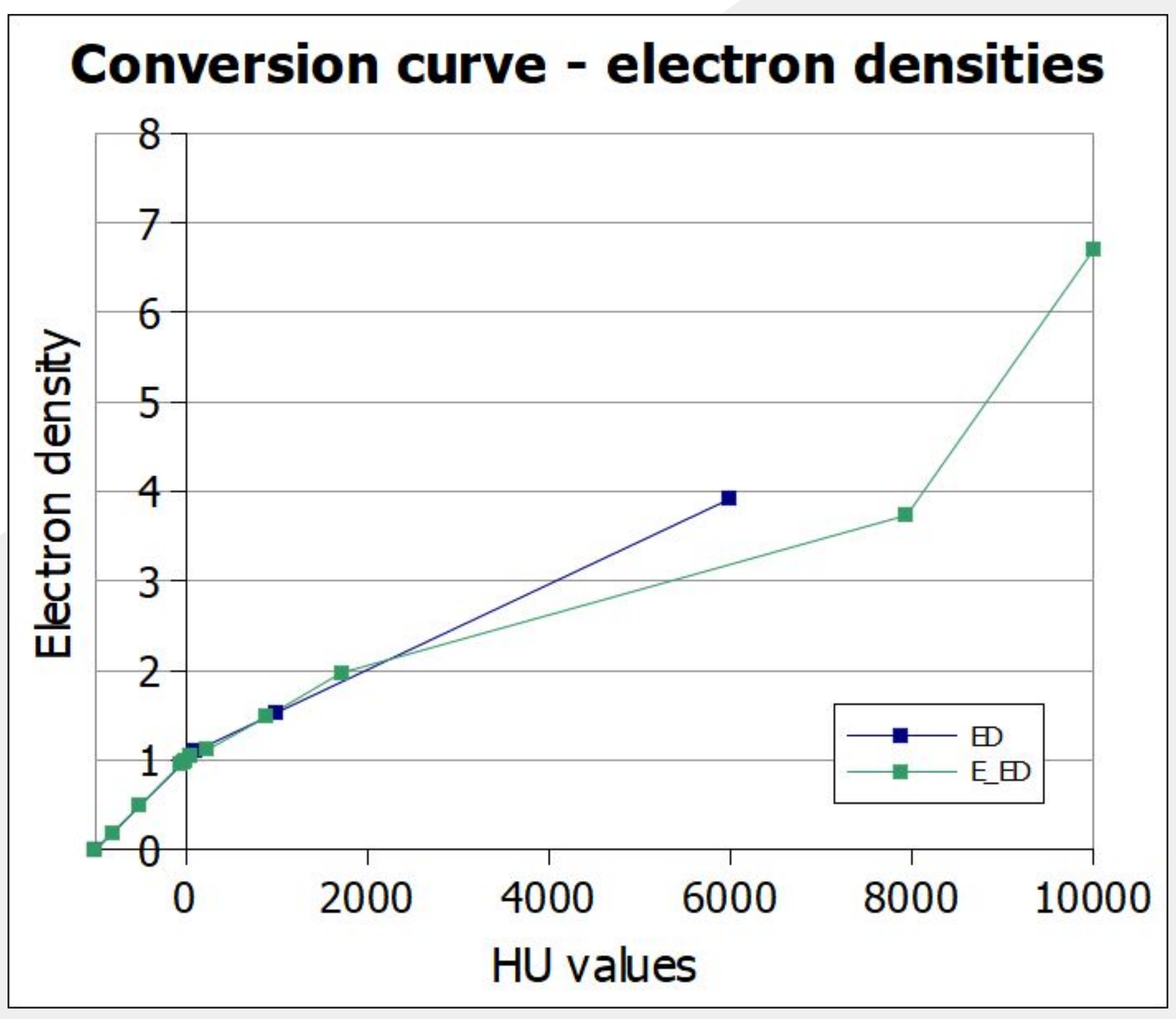
This study aims to analyse the influence of two conversion curves (CC), the standard one and extended to the high densities, on TPS calculations in the presence of metallic ports. Next, compare these calculations with radiochromic film measurements.

Materials and methods Two temporary tissue expanders with integrated ports (Nagor/Mentor) and one with a distal port (Mentor) were tested. During CT collection and measurements, ports were placed horizontally on a 15 cm water-equivalent base (slabs). CT was reconstructed using metal artefact reduction algorithms and an extended HU scale. Calculations for a single beam were done in the Eclipse TPS (v 15.6, Varian Medical Systems) for 6MV, 6MVFFF, 15MV beams and the Analytical Anisotropic Algorithm (AAA) (electron density conversion curve - ED). For 6MVFFF (flattening filter-free) beam, additional calculations using the Acuros XB (AXB) algorithm (dose-to-medium option, mass density conversion curve - MD) were added. Calculations were based on two versions of conversion cures. The maximum values of standard range conversion curves were 6 000 HU for the ED and 2 832 HU for the MD. Extended conversion curves (E_ED and E_MD) were lengthened to high Z materials (up to 10 000 HU). Measurements were done on TrueBeam (AAA) and EDGE (AXB) machines. A fixed number of monitor units was set during the calculations and measurements (525 MU for 6MV and 6MVFFF beams and 900 MU for 15MV beam). Pieces of Gafchromic EBT3 films were placed under slabs of appropriate thickness. For 6MV and 6MVFFF beams, measurements were taken at depths of 1, 2, 5, 10, 14, 20 and 50 mm below the ports. For 15MV beams, the depths were 1, 2, 5, 14, 25, 30 and 50 mm. Depths for both energies were chosen to fit the dose distribution in a build-up region and a maximum dose location. For two conversion curves ranges, doses calculated in TPS relative to the measured ones were compared.









***Top:** Metallic integrated port of Nagor tissue expander (1); distal port (Mentor) during measurements (2)*

***Left:** MD and ED conversion curves ranges*

Results Better agreement between measured and calculated doses was obtained for both extended conversion curves. Extended conversion curves had a more significant influence on improving AAA dose calculation accuracy than for the AXB algorithm. For integrated ports 98% and 80% of measurement points were improved, respectively. Greater improvement in results was noted at shallow depths (1-5 mm). However, the differences between system calculations and measurements for these points were still greater than for deeper located points. For AAA algorithm, depths to 5 mm and integrated ports, the average improvement was: 6.1 percentage points (pp) and 10.3pp for 6MV, 6.7pp and 10.9pp for 6MVFFF, and 3.0pp and 5.8pp for 15MV beams for Nagor and Mentor, respectively. For measurements at depths deeper than 5mm, it was respectively 3.5pp and 6.7pp, 3.9pp and 7.5pp, 2.8pp and 4.4pp for 6MV, 6MVFFF and 15MV beams. For the distal port, the maximum difference was 0.3pp. No such significant depth-dependent differences were observed for the AXB. The agreement was improved on average by 0.8pp (Nagor) and 0.5pp (Mentor) for the integrated ports and 0.7pp for the distal port. Overall for the distal port, better results were achieved for 52% (AAA) and 71% (AXB) of all measurement points. For all other points, the difference between calculations using E_MD and MD conversion curves was not observed or did not exceed the value of 1cGy. The maximum difference for the distal port was 0.3pp (AAA) and 1.8pp (AXB), favouring the extended conversion curve.

Conclusions TPS calculations based on the extended conversion curves show higher agreement with doses measured under metallic ports of temporary tissue expanders. It is more pronounced for integrated ports than for distal ones. Clinical implementation of extended conversion curves seems necessary when patients with implanted metal components are irradiated.