to choose (and adhere to!) a target volume(+/- margin)/prescription dose relationship. Small margins result in large dose differences reported.
to define the adequacy levels of the prescribed/delivered dose relationship, as is done with all other areas of radiotherapy. This should help us decide which and when to apply corrective actions.
The other two arms of the project are proceeding and they are essential to validate some of these points.
Brachytherapy of the prostate has, so far, yielded results as good as the other two standard treatments (RP or EBRT) although, as we see, not all aspects of the procedure have yet been well characterized. Chances are that, with better standardization and quality assurance of the technique, those results can be further improved, since brachytherapy is still the most conformal form of radiotherapy widely available.

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Recommendations of the Braphyqs Prostate Sub-Group, the physics part of the questionnaire

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In February 2004 a questionnaire, developed of the members of the Braphyqs-2 was distributed to all the centres which, to our knowledge, are performing TIPPBT in Europe. The questionnaire consists in eight sections where both physics and clinical aspects of the procedure have been investigated.
One of the main findings concerning the physics-related aspect of the questionnaire, was the lack of a calibration laboratory for permanent brachytherapy sources joining to the discrepancy among the protocols to control the sources activity (when?, how? with how many seeds?). This was reflected on the used of the activity certified by the company during the planning.
No consensus exists concerning either the definition of the CTV and the PTV or the margins to be applied between this two contours during the volume study, although 54.4% (31/57) of the centres define the PTV as prostate + margin (3-5 mm in the most used margin). The survey highlights the differences in dosimetric parameters and constraints following during the planning; in fact although there is modest agreement to consider the value of V100 to evaluate the coverage of the target (40.4% (23/57)) , no consensus exists concerning the dosimetric constraints for the organs at risk (rectum and urethra).
Regarding the post-plan evaluation, 61.4% (35/57) of the centres performs the post-implant evaluation 1 month after the implant; CT is still the standard for the post-plan dosimetry (86% (49/57)), although there are centres where MRI only is used. D90 and V100 are the most common dosimetric parameters used to judge the implant, but a major concern is that most centres have no definition regarding the quality of the implant (no definition given: Adequate: 50.9% (29/57) Acceptable: 61.4% (35/57) Inadequate: 56.1% (32/57)).
The need to have both an European certified laboratory for the calibration of the chamber (used during the check of the source activity) and a recommended protocol to perform the measurements is strongly felt by the Braphyqs-2 members.
Moreover, the survey points out how is necessary to write down recommendations regarding dosimetric parameters and constraints to be use during the planning of the treatment as well as to be recorded during post-implant evaluation. In particular, which kind of dosimetric parameters to be collected for organs at risk are to be analysed taking into account the peculiarity of the permanent brachytherapy dose distribution (in fact very steep dose gradients close to organs at risk can be found).

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Recommendations of the Braphyqs Prostate Sub-Group: Summary and directions for new recommendations

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Five years ago, the ESTRO/EAU/EORTC published their recommendations on permanent seed implantation for localised prostate cancer. As it was stated in the introduction of the article, the aim was to offer a guidance to those embarking on brachytherapy and to indicate the factors which may be related to successful outcome. At present however, teams that start applying this treatment technique and that are searching for clear guidelines will still experience that only few data on recommendations of physical parameters are available. Multiple institutions have reported data on target definition, implant dosimetry using different techniques and modalities, but none is considered standard. These considerations have led the BRAPHYQS group of the ESTRO to perform an evaluation of the existing parameters interfering with target definition and pre, intra- and post-implant dosimetry by sending out a survey in the different European countries.
The huge variability observed in the answers received confirms not only a large degree of indistinctness but also the need for additional guidelines. Based on the results from this questionnaire, on the clinical experience of the members of the workgroup, and on an extensive review of the literature, the onset to a large debate on practical guidelines and additional recommendations will be given.
In order to increase uniformity in treatment delivery and dose reporting proposals for guidelines in each step of the procedure will be given. The ultrasound acquisition method, the delineation and definition of GTV, CTV and PTV, the dosimetric parameters useful in pre-implantation dosimetry, definition/delineation of the critical organs, the dosimetry regarding these critical organs, the advantages and drawbacks of real-time/virtual dosimetry, the benefits and disadvantages regarding post-implant dosimetry, dosimetrical parameters necessary and useful in post-implant dosimetry, the most appropriate method (ultrasound, CT, MRI, or a combination) and ultimate time period for this post-implant dosimetry, the eventual need for additional quality parameters, etc. will be discussed.
As stated, this presentation only aims to be the start for further debate on these items, eventually resulting in an addendum to the known recommendations.

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The use of phantoms for quality assurance in the post-planning procedure of permanent seed implants

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Introduction: In 2003, the Braphyqs group (task group in the ESTRO ESQUIRE project) extended its QA program by defining new objectives with respect to quality assurance in prostate seed implants. One objective of the group is to develop new QA phantoms, which allow checking the reliability and the accuracy of the post-planning seed reconstruction procedure. Two approaches were made: one solid phantom for the usage in CT and with radiographs, and a gel-based phantom suitable for MRI measurements. In this study, we present the first results of seed reconstruction checks performed with the solid phantom in six centers participating in this Braphyqs subtask. In a later phase, the results will be cross -correlated with MR-based reconstructions.
Materials and Methods: With the Perspex® made solid phantom, different seed configurations can be simulated by placing non-radioactive (dummy) seeds very accurately in special inserts that are drilled in exchangeable slabs. A particular test pattern consisting of 17 dummy seeds (InterSource125, IBT) was created. The geometrical seed arrangement includes seed positions over a large longitudinal distance (42mm), tilted seeds

(α=20°), seeds in a close distance (d=2mm), seeds touching each other at their vertices, four seeds in a square pattern (l=10mm) and seeds in a spiral staircase form. At six different sites with seed implant experience (Barcelona, Brussels, Kiel, Leuven, Mount Vernon, Vienna) a typical CT- or radiograph-based post-planning procedure was performed with the phantom, using the same parameters as for clinical patients. The aim of this cross checking was to test the reliability and precision of the whole post-planning chain for seeds, including data acquisition (CT or X-ray imaging), image transfer and image handling in the TPS (used TPSs: BrachyVision 7.0, Pinnacle 6.0m, Plato 14.2.4/5, Spot Pro 2.1, VariSeed 7.0/7.1). The slice thickness used in the participating institutes ranges from 2 mm to 4 mm (slice spacing 2 to 5 mm). All centers performed reconstruction of the seed positions and the results were compared with the well-known dummy seed coordinates in the solid phantom.

Results: Altogether 13 datasets were obtained from the six participating centers. Some sites used two different TPSs or varied the CT scan parameters. Only two institutes used film reconstruction techniques. In every case the 17 seeds of the test pattern were detected, although the seed number was not known. For the CT scans the following was observed: the largest displacements were measured in longitudinal direction, the overall standard deviation (SD) for the centers was 0.9 mm with a range between 0.2 and 1.3 mm for the individual sites. Displacements in x- and y-direction resulted in an overall SD of 0.2 mm (between 0.1 and 0.3 mm for the institutes). In general, larger mean displacements in longitudinal direction were observed in image sets with larger slice thickness and/or inter slice spacing.

No significant differences could be found between spiral and axial CT scans, nor between the tested TPSs. For one TPS, problems with the automatic seed finding algorithm were reported with seeds at close distance.

Radiograph-based seed reconstruction was used in two centers only. As expected, errors in the reconstruction algorithm occurred with overlapping seeds.

Conclusion: The solid phantom was found to be a handy and valuable QA tool for the assessment of the seed reconstruction accuracy in post-implant procedures. Future work will focus on the gel-based phantom in order to compare the intrinsic accuracy of the CT and MR based reconstruction approach.

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Assessment of the intrinsic accuracy of CT- and MR-based postimplant seed reconstruction with a dedicated prostate phantom

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Introduction: The reliability and accuracy of seed implant postplanning depends on many factors, the most important being target delineation precision, seed localisation accuracy and correctness of calculation parameters/algorithms. Several studies showed that target delineation is more precise with MR than CT. However, there is hardly comparative data available on seed localisation accuracy of CT-and MR-based reconstructions. In this study, we investigate the intrinsic accuracy of seed detection for both imaging modalities with a dedicated phantom.

Methods: The phantom construction is based on previous phantom developments (1). The phantom consists of a PMMA container filled with agarose slabs in which dummy seeds can be accurately implanted. Besides similar density to tissue, agarose possesses comparable T1- and T2-relaxation times as prostate tissue (T1=1207ms, T2=66ms for agarose, T1=1317ms, T2=88ms for prostate). This guarantees identical imaging characteristics (size of signal void, position distortions due to field inhomogeneities) in MRI as in prostate, regardless of the scan parameters. This is important as imaging characteristics may influence the seed visualisation and hence the localisation accuracy.

The phantom has a coordinate system consisting of N-shaped tubes which allow absolute determination of seed positions with respect to an origin fixed to the phantom. This is in contrast to our previous phantom, where deviations could only be determined relatively by comparing distances between reconstructed and exact seed coordinates.

60 seeds were implanted according to a clinical geometry with a strand-like pattern, including tilted and shifted seeds. CT and MR (1.5T) scans were performed with 3, 4 and 5 mm slice spacing using clinical sequences (for MR: T1-weighted, FFE, TR/TE=320/4.3 ms, in plane resolution 0.73x0.73 mm). Seed locations were reconstructed with Variseed 7.1 and compared with the exact locations (absolute assessment). In addition, distances between reconstructed and exact seed coordinates were compared (relative assessment). The results of the 60-seed geometry were compared with 2 other geometries (66 and 67 seeds) implanted in a phantom without coordinate system.

Results: Mean deviations are listed in table 1. Deviations within slices (x, y-direction) are neglectable. For all cases, mean deviations are larger in longitudinal direction but still < 2 mm, which is acceptable for clinical use. MR-based reconstructions are in general less accurate, especially in longitudinal direction, than reconstructions on CT. This is because artefacts of seeds which are projected on multiple slices are more pronounced on MR than CT.

The implementation of the coordinate system provides more accurate information. For instance, a larger deviation is observed for CT with 5mm than 3 and 4mm slice distance. Although this is logically expected, it was not noticed with the relative assessment: as many seeds are placed in a 10mm strand-like configuration, shifts in z-direction (seeds in between slices) go unnoticed when only distances are considered.

Conclusion: With an absolute coordinate system it is possible to trace seeds with large deviations. This is helpful to learn to interpret images in order to perform better seed reconstructions in clinical patients.

(1) De Brabandere M, Kirisits C, Lang S, Venselaar J, Georg D, Huyskens D, A prostate phantom for quality control of MR and CT based postimplant seed reconstruction, Radiotherapy and Oncology, Vol. 71: S4-S4 8 Suppl, 2004.

Table 1: Mean deviation for 3 different seed geometries

		CT 3mm	CT4mm	CT5mm	MR3mm	MR4mm	MR5mm
		mean absolute deviation in mm					
60 seeds	x	0.5	0.3	0.4	0.5	0.5	0.5
	y	0.2	0.2	0.3	0.5	0.4	0.5
	z	0.8	0.8	2.1	2.0	1.5	1.8
		mean relative deviation (distances) in mm					
60 seeds		0.6	0.6	0.9	1.5	1.2	1.2
66 seeds		0.9	1.1	0.7	1.8	1.4	1.4
67 seeds		0.7	0.9	0.7	1.6	1.4	1.3