Original article

# Commissioning of brachytherapy module of Oncentra MasterPlan treatment planning system

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## Abstract

**Purpose:** To describe the tests that have been performed in order to commission the Brachytherapy module, version 3.2, service pack 3.0, of the Oncentra MasterPlan treatment plan system (OB), from Nucletron. The results were benchmarked against those obtained with the Plato system, v 14.3.7, also from Nucletron, used in the clinical routine.

**Material and methods:** Commissioning was performed taking Plato, v 14.3.7 as the standard TPS used in clinical practice. Commissioning tests were divided into two categories: i) simple geometric catheter configurations and ii) clinical intracavitary gynaecological and interstitial breast implants. For category i), also manual independent point dose calculations following the TG-43 dosimetry protocol were included in the comparisons. For category ii), the treatment plan comparisons were based on the calculated dose distributions in CT axial plans and on the dose-volume quality indexes following the local clinical acceptance criteria. Similar optimization tools were used in both systems. IPSA in OB was tested for planning interstitial breast implants and compared with the optimization process used with Plato in the clinical routine.

**Results and Conclusions:** Regarding the point dose calculations, the agreement was better than 1%. For the clinical compared cases and using the same optimization tools all plans ended in similar dose distributions and very close quality indexes. Nevertheless, for endovaginal treatment plans, a slightly different value for the DTGR parameter had to be used (0.452, instead of 0.5 used as default in PLATO) in order to achieve the same dwell time for each activated source dwell position. Concerning interstitial breast implants, the IPSA algorithm constitutes a fast tool to reach a close clinical acceptable solution but Graphical Optimization is still needed. Considering these results the OB module was accepted for clinical use despite some persisting limitations, such as no consideration of heterogeneities or options for applicator shielding.

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**Key words:** TPS commissioning, dose calculations, Oncentra Brachy.

## Purpose

The performance of the treatment planning system (TPS) is a key component in any radiation therapy process. Many studies have been done to assess available treatment planning systems as well as to provide guidelines to be followed in the commissioning process, mainly for external beam calculations [1-3]. Concerning brachytherapy, and mainly due to developments such as the use of remote afterloading, the availability of CT, MR or US imaging for structure delineation and source path definition or the use of low energy gamma ray sources, an increasing interest in the improved accuracy of brachytherapy dose calculations has emerged [4-6]. In order to help in organizing a quality assurance program there are some publications providing useful guidelines, namely for the quality control of treatment planning systems used in brachytherapy [3, 7].

The purpose of this work is to report the results of the commissioning process of the Oncentra Brachytherapy module recently available for the Oncentra MasterPlan treatment planning system of Nucletron. A set of tests has been identified in order to have a comprehensive assessment of the accuracy of dose calculations implemented in Oncentra Brachy (OB) when compared with the results of Plato, version 14.3.7, also from Nucletron, that has been used in the local clinical routine for the last years and was thus taken as a reference in these comparisons. The delineated set of tests included both simple geometrical catheter configurations and real clinical cases both for intracavitary gynaecological implants and interstitial breast implants. Point dose calculations have been compared for the simpler geometrical cases. All clinical plans have been evaluated under the local clinical acceptance criteria that are based on dose-volume quality indexes. Both dose-volume histogram (DVH) parameters and visual inspection of the resulting dose distributions have been compared. Local clinical calculations follow different dosimetry protocols that use

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different optimization approaches. The same processes have been followed in the OB system under consideration. New optimization tools available in OB and not in our configuration of Plato, such as the IPSA algorithm, have also been tested in order to achieve acceptable clinical plans.

## Material and methods

Oncentra Brachy, version 3.2, service pack 3.0 was benchmarked against Plato, version 14.3.7, both from Nucletron.

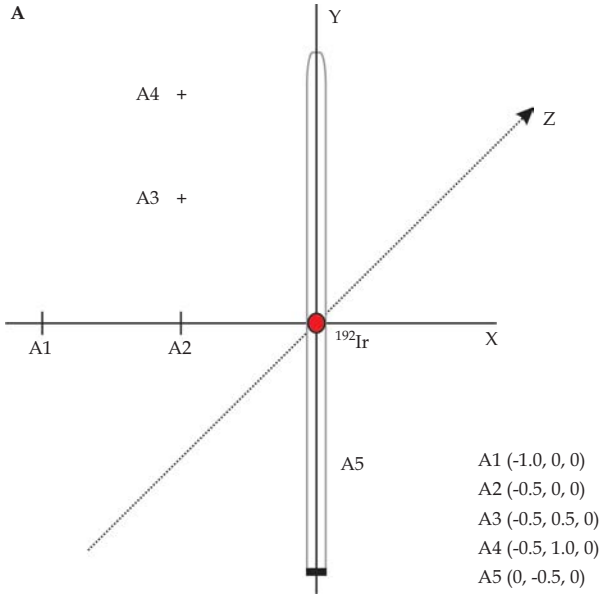
Commissioning tests were divided into two categories: simple geometric catheter configurations and clinical implant situations for endovaginal intracavitary and interstitial breast implants.

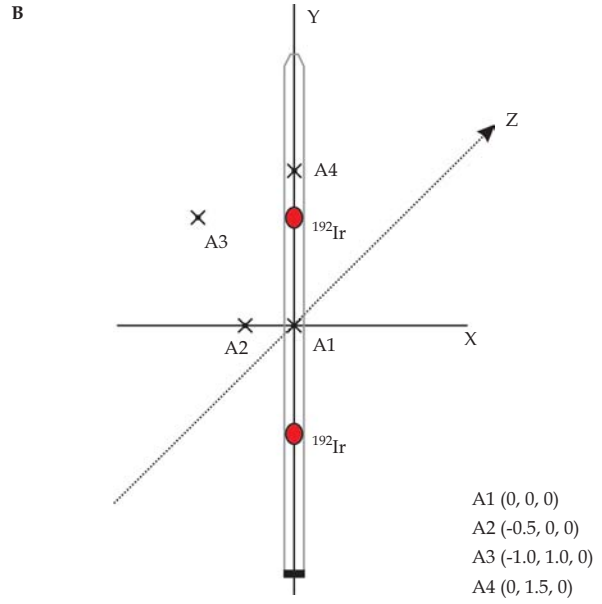
### *Simple geometric catheter configurations*

For these tests, three simple configurations were created. For two of them, see Figs. 1A and 1B, only one catheter was defined. It was aligned along the Y axis and centred with the XYZ coordinate system. For a third configuration, see Fig. 1C, two catheters were defined, also parallel to the Y axis but with 1 cm separation between them. For each configuration, one or two dwell positions were activated. According to the recommendations of ESTRO Booklet no. 8 and assuming a cylindrical symmetry, a set of points was defined around the catheter(s) in order to calculate the delivered dose. The dose was prescribed to one of the defined points and it was considered to be 1 Gy.

An Excel worksheet was used for independent point dose calculations following the TG-43 dosimetry protocol [8]. Published dosimetric data were used for the $^{192}$Ir source [9] which is installed in the TCS, v2, μSelectron HDR treatment unit, from Nucletron.

For all these calculations a $^{192}$Ir source strength of 18855.19 cGycm$^2$/h was used.



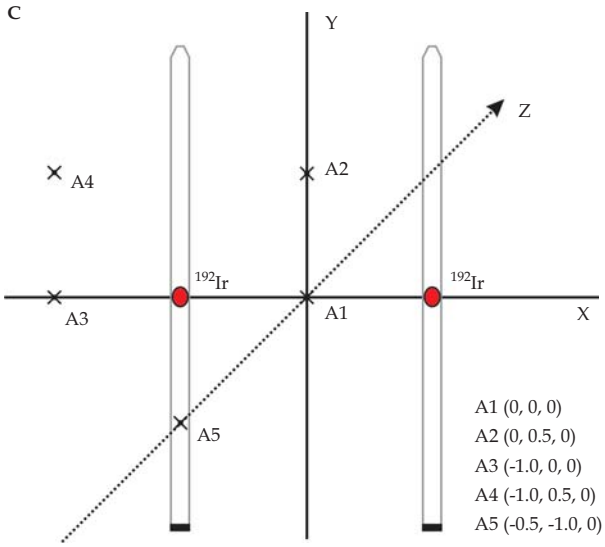




**Fig. 1A.** One catheter defined along the Y axis and centred with the XYZ coordinate system. The dwell position that was activated is located at the (0, 0, 0) position. $A_2$ with coordinates (-0.5, 0, 0) corresponds to the normalization point. $A_1$, $A_3$, $A_4$ e $A_5$ have, respectively, the following coordinates: (-1.0, 0, 0), (-0.5, 0.5, 0), (-0.5, 1.0, 0) and (0, -0.5, 0); **B.** One catheter aligned through the Y axis and centred with the XYZ coordinate system. Two dwell positions were activated, respectively, at (0, -1.0, 0) and (0, 1.0, 0) coordinates. $A_2$ with coordinates (-0.5, 0, 0) corresponds to the normalization point. $A_1$, $A_3$, and $A_4$ have, respectively, the following coordinates (0, 0, 0), (-1.0, 1.0, 0) and (0, 1.5, 0); **C.** Two catheters aligned parallel to the Y axis and with a 1 cm separation between them. $A_3$ with coordinates (-1.0, 0, 0) corresponds to the normalization point. $A_1$, $A_2$, $A_4$ e $A_5$ have, respectively, the following coordinates: (0, 0, 0), (0, 0.5, 0), (-1.0, 0.5, 0) and (-0.5, -1.0, 0)

### *Clinical implant cases*

**Endovaginal intracavitary implants**

At our radiotherapy department, using Plato TPS, endovaginal intracavitary gynaecological implants are performed with the cylinder applicator, from Nucletron. According to the clinical prescription a certain length, starting from the most distal position in the applicator, is activated. The applicator diameter is chosen in order to best fit the patient's anatomy. The source step is 0.5 cm.

The dose is prescribed to the applicator surface at four applicator points, defined centred with the activated length. In order to flatten the dose distribution, a set of dose points is created using the option *axis points*. The dose distribution is optimized on those dose points and on distance, considering the dwell time gradient ratio (DTGR) equal to 0.5.

According to the respective clinical prescription, three treatment plans of patients who had already been treated were reproduced in OB TPS.

**Interstitial breast implants**

A set of CT images and corresponding delineated volumes of four clinical cases (already treated patients) were randomly chosen for this study. The clinical target volumes (CTVs), corresponding to the volume encompassing the surgical clips with a margin of 7 mm or 10 mm [10], ranged from 7 $cm^3$ to 22 $cm^3$. These volumes are always delineated in the Oncentra MasterPlan Target Definition Module (common to external beam calculation modules) and then exported to Plato. A homemade template is used for breast implants [11]. Our local clinical dosimetry protocol comprises a mixed dosimetry system that includes the auto-activation of source dwell positions along the CTV plus a 5 mm margin and the definition of basal points throughout the activated length (like in the stepping source dosimetry system). The dose prescription to 85% of the dose received by the basal points is modified by the use of the graphical optimization tool in order to fulfil the plan acceptance criteria, which are based on dose-quality indexes. The required coverage index is CI > 95%; for the overdosage index, OI, values that correspond to an absolute volume less than 6 cc are accepted, and to reach a conformal treatment plan, the conformity index, COIN, should be greater than 0.6 [10, 12-14].

The Plato treatment plans were reproduced in OB starting from the catheter reconstruction because, at this time, it is not possible to export treatment plans from Plato to the OB system. Treatment plan comparisons were done based on the calculated dose distributions, visualized on the CT axial images, as well as on the calculated dose-volume quality indexes (CI, OI and COIN).

In OB the IPSA algorithm was also tested and the optimized treatment plans were compared with the ones previously calculated in Plato.

The IPSA algorithm implies the definition of a set of dose objectives and their corresponding weights. So, the parameters Dose and Activation margins (mm) were set to zero, which prevents the dose distribution being expanded outside the delineated CTV and the activation of source dwell positions outside the target. In what concerns the target, just the parameter related to the minimum dose at the CTV surface was used and its weight was set to the maximum value of 200. In order to limit the volume irradiated with a dose higher than twice the prescribed dose, an auxiliary structure was defined, which corresponded to the external contour excluding the CTV. The objective for this volume was a dose around 80% to 100% of the prescribed dose with a relative importance of 100.

If the target was less than 5 mm from the skin, the external contour was also used and the maximum dose to its surface was set as equal to half the prescribed dose, with a relative importance of 150. Of course these settings constitute a starting point, which must be tuned for each case.

For DVH calculations, the number of sampling points of 100 000 was chosen because it corresponds to the maximum number allowed in Plato. Regarding the number of bins, this parameter cannot be defined in Plato. The maximum allowed value of 800 was used in the OB system. Regarding the calculation matrix, which is also possible to be defined in OB, the voxel was set to 1 $mm^3$.

The set of activated positions and the corresponding dwell times obtained in OB with IPSA were manually introduced backwards in Plato. The two dose distributions were visually compared in each CT slice in both systems.

## Results

### *Simple geometric catheter configurations*

Tables 1A to 1C show the results of the calculations, using Plato, OB and the independent manual calculation, in each of the defined points, considering the configurations shown in Figs. 1A to 1C, respectively. There was a very good agreement as the percentage standard deviations were less than 1% for all the calculation points in all three catheter arrangements.

For each configuration, the total treatment time, calculated by both TPS, was very similar.

### *Clinical implant situations*

**Intracavitary gynaecological implants**

Table 2 exemplifies, for one of the planned endovaginal implants, the obtained time pattern as well as the global treatment time in OB benchmarked against Plato. If a value of 0.5 is considered for the DTGR parameter (on the left in Table 2), the percentage difference in terms of total treatment time is -1.1%. Nevertheless, if we look into the time spent by the source at each activated dwell position, although both TPS attribute a higher weight to the extreme dwell positions, OB calculations resulted in a smoother time distribution.

Making in OB a slight change in the DTGR parameter, specifically using the value 0.452 instead of 0.5, resulted in a time pattern equivalent to the one obtained with Plato for both the global and the partial time distribution (on the right in Table 2).

As can be seen in Fig. 2, the dose values calculated at each defined axis point were also similar. In terms of the dose distributions, analysed on the basis of the length and width of the 100% isodose, the plans generated by the two TPS were equivalent. For these measures the *ruler* tool in Plato and the *measures – distance* tool in OB were used.

### Interstitial breast implants

The first observed difference between the two TPS was related to the CTV volume calculation, which was done on both TPS, indirectly, through DVH calculation and not using dedicated tools. In Fig. 3, the CTV volumes are presented for each planned breast case as well as the percentage differences. As expected, the smaller the volume, the greater the relative difference between the calculated volume values. Both CTVs had been delineated in the OMP Target Definition module but the computed volume turned out to be different in OB and Plato. The reason is related to the different strategies used by each TPS to calculate the volume of delineated structures. In Plato, the volume calculation is based on random points within the volume, and in OB the volume is calculated through the reconstruction of a 3D matrix.

Figures 4 to 6 show the calculated values for the coverage index, CI, the conformity index, COIN, and the overdosage index, OI, respectively. From the point of view of the calculated dose-volume quality indexes, the treatment plans in OB turned out to be equivalent and the planning sequence very similar to that of the Plato system. Some local differences were observed in terms of the individual catheters that were activated, but this could be justified by the fact that the complete catheter reconstruction had to be repeated in OB, which may introduce small differences in the source path definition.

In what concerns the use of the IPSA algorithm, the results for the calculated quality indexes CI, COIN and OI are shown in Figs. 7, 8 and 9, respectively, and compared with the same parameters from the original treatment plans, calculated with Plato TPS. From this point of view the treatment plans could be considered equivalent. A slightly better COIN has been achieved at the expense of a higher OI, although below the limit value in our clinical practice.

The major differences have been obtained in the number of activated catheters. As the parameters Dose and Activation margins within IPSA are constrained to zero, the number of activated catheters is substantially lower than used to be the case with our dosimetry implemented protocol. In consequence, the pattern of activation resulting from IPSA optimization was considerably different from the activation pattern achieved with the dosimetry system used in our clinical practice, which is a mix between the standard stepping-source dosimetry system and the conformal dosimetry system. However, the IPSA optimized plan manually replicated in the Plato system resulted in a dose distribution with the same shape in each CT axial slice.

### Discussion

Point dose calculations were performed in order to test the adequate use of the published dosimetric data for the $^{192}$Ir source of the HDR µSelectron treatment unit and, simultaneously, to check the correct implementation of the TG-43 dosimetry protocol in OB. The calculations independently performed were consistent within 1% with the results of Plato and OB.

**Table 1.**

**A.** Point dose calculations and percentage standard deviations for catheter geometry shown in Fig. 1A, using the Plato, OB TPS and manual calculations

| Points to Dose Calculation | PLATO | OB | Manual Calculations | δ (%) |
|---|---|---|---|---|
| | D (Gy) | | | |
| $A_1$ | 0.2577 | 0.2577 | 0.2553 | 0.53 |
| $A_2$ | 1.000 | 1.000 | 0.9909 | 0.53 |
| $A_3$ | 0.5085 | 0.5088 | 0.5074 | 0.15 |
| $A_4$ | 0.1879 | 0.1880 | 0.1859 | 0.64 |
| $A_5$ | 0.7285 | 0.7285 | 0.7223 | 0.49 |

**B.** Point dose calculation and percentage standard deviations for catheter geometry shown in Fig. 1B, using the Plato, OB TPS and manual calculations

| Points to Dose Calculation | PLATO | OB | Manual Calculations | δ (%) |
|---|---|---|---|---|
| | D (Gy) | | | |
| $A_1$ | 0.8717 | 0.8709 | 0.8587 | 0.84 |
| $A_2$ | 1.0000 | 1.0000 | 1.0035 | 0.20 |
| $A_3$ | 0.8112 | 0.8104 | 0.8099 | 0.08 |
| $A_4$ | 2.1988 | 2.1967 | 2.1947 | 0.09 |

**C.** Point dose calculation and percentage standard deviations for catheter geometry shown in Fig. 1C, using the Plato, OB TPS and manual calculations

| Points to Dose Calculation | PLATO | OB | Manual Calculations | δ (%) |
|---|---|---|---|---|
| | D (Gy) | | | |
| $A_1$ | 1.7928 | 1.7928 | 1.7928 | 0.00 |
| $A_2$ | 0.9117 | 0.9121 | 0.9121 | 0.03 |
| $A_3$ | 1.000 | 1.000 | 1.000 | 0.00 |
| $A_4$ | 0.5489 | 0.5492 | 0.5492 | 0.03 |
| $A_5$ | 0.2542 | 0.2543 | 0.2543 | 0.02 |

**Table 2.** Global and partial treatment times for an endovaginal gynaecological treatment, planned in Plato and OB. Within Plato these treatment plans are optimized on dose points and on distance, using a value of 0.5 for the DTGR parameter (results shown on the left). In order to reproduce in OB the same time pattern a slightly different value of OB had to be used (results shown on the right)

| | DTGR = 0.5 | | | DTGR = 0.452 | |
|---|---|---|---|---|---|
| | Plato | OB | Δ (%) | OB | Δ (%) |
| $t_{Total}$ (s) | 657.1 | 649.9 | -1.1 | 656.80 | -0.05 |
| $t_{Partial}$ (s) | | | | $t_{Partial}$ (s) | |
| ASDP 1 | 122.5 | 116.2 | -5.14 | 122.5 | 0.00 |
| ASDP 3 | 98.5 | 95.2 | -3.05 | 98.5 | 0.00 |
| ASDP 5 | 65.5 | 67.0 | 2.29 | 65.6 | 0.15 |
| ASDP 7 | 42.6 | 47.0 | 10.33 | 42.6 | 0.00 |
| ASDP 9 | 42.5 | 46.9 | 10.35 | 42.6 | 0.00 |
| ASDP 11 | 65.3 | 66.6 | 1.99 | 65.2 | -0.15 |
| ASDP 13 | 98.1 | 95.0 | -3.16 | 98.0 | -0.10 |
| ASDP 15 | 122.1 | 115.7 | -5.24 | 121.9 | -0.16 |

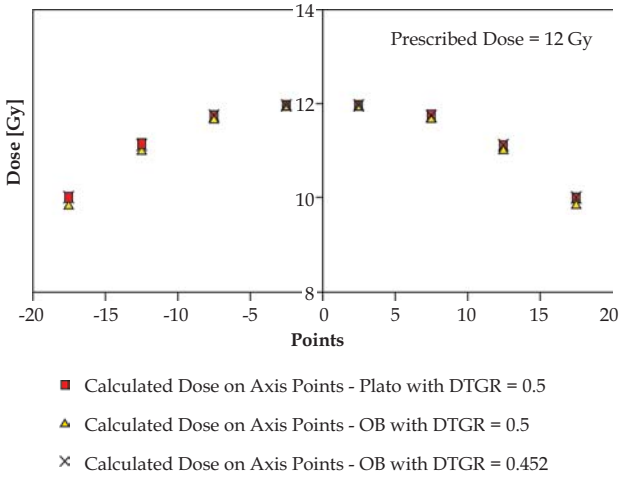



**Fig. 2.** Dose on Axis Points, defined on applicator surface at every activated dwell position, calculated both with Plato, DTGR = 0.5, and OB both with DTGR = 0.5 and DTGR = 0.452

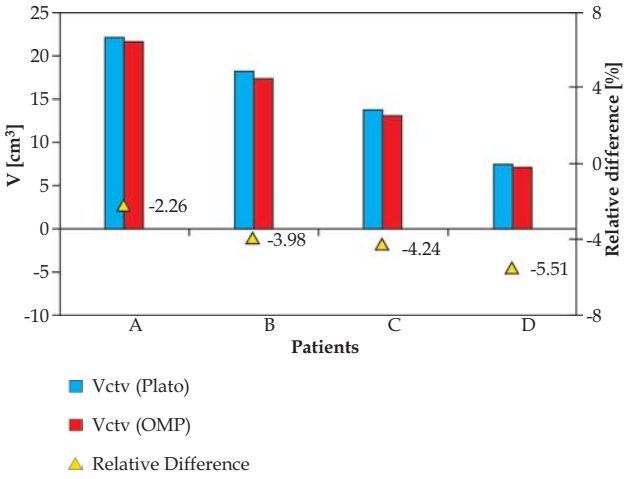



**Fig. 3.** CTV calculated volumes in Plato and OB. The percentage differences, considering the values calculated by Plato as reference, are also shown

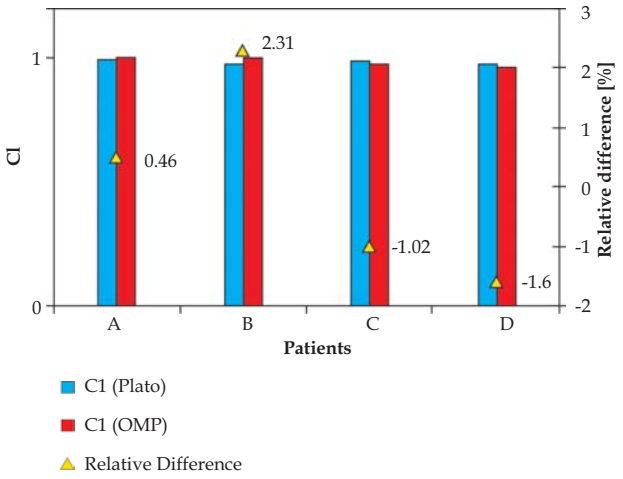



**Fig. 4.** Coverage index, CI, calculated for each treatment plan planned in Plato and OB according to the local dosimetry protocol

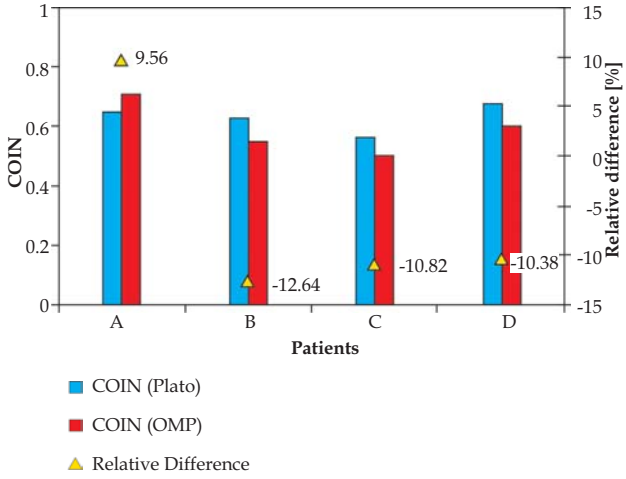



**Fig. 5.** Conformity index, COIN, calculated for each treatment plan planned in Plato and OB according to the local dosimetry protocol

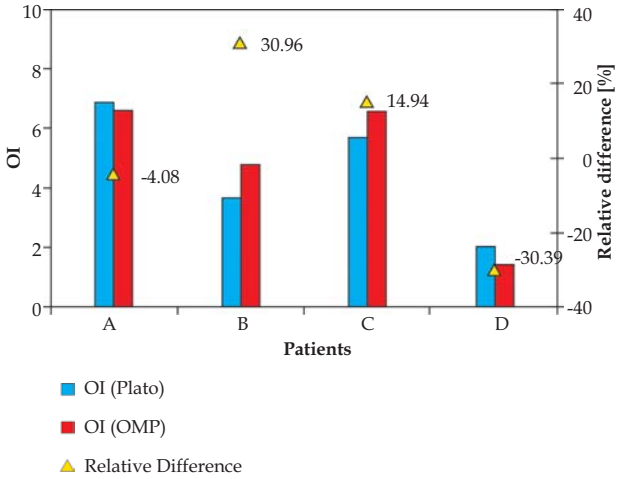



**Fig. 6.** Overdosage index, OI, calculated for each treatment plan planned in Plato and OB according to the local dosimetry protocol

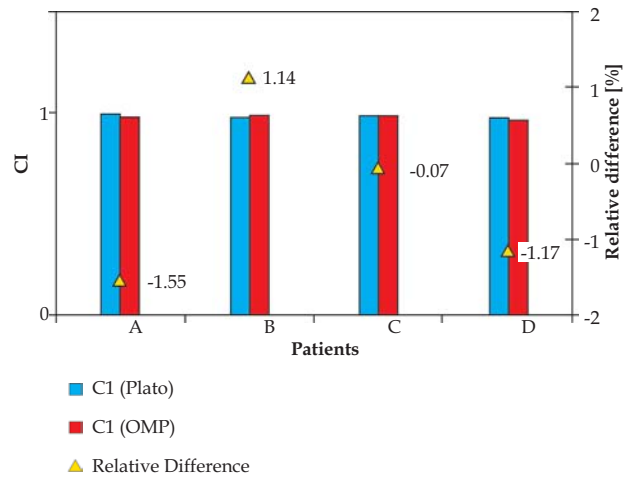



**Fig. 7.** Coverage index, CI, calculated for each treatment plan planned in Plato and OB, using the IPSA algorithm

Regarding the endovaginal intracavitary brachytherapy implants, we have found that the calculated treatment plans in both TPS were consistent with each other. Nevertheless, in order to reproduce the treatment plans accepted in our clinical practice, a slight change in the DTGR parameter had to be assumed.

Concerning more complex situations, such as interstitial breast brachytherapy implants, we have been able to reproduce our local dosimetry protocol. From the point of view of the calculated dose distributions, inspected on each CT slice, as well as from the calculated values for the dose-volume quality indexes, it was possible to achieve similar treatment plans, fulfilling the local clinical acceptance criteria.

The use of the IPSA tool, available in OB, constitutes an accelerating factor in the treatment plan workflow. The obtained solutions, once adequate dose objectives and their respective weights were defined, were close to the clinically acceptable solutions. Nevertheless, graphical optimization was still needed.

## Conclusions

The recently installed Oncentra Brachy Module of OMP Nucletron was benchmarked against Plato TPS used so far in our clinical routine. Different plans were tested from simple geometrical catheter configurations to clinical implants corresponding to intracavitary gynaecological implants and interstitial breast implants. Having as our main purpose the commissioning of the OB version 3.2, service pack 3.0, we have concluded, at the end of this set of tests, that it is possible to use it in clinical routine. The workflow and available menus are similar to Plato TPS so the migration will be quite straightforward. Nevertheless, we do stress here some limitations, namely the non-consideration of heterogeneities and the unavailability of shielding options for either gynaecological or rectum and anal canal cases.

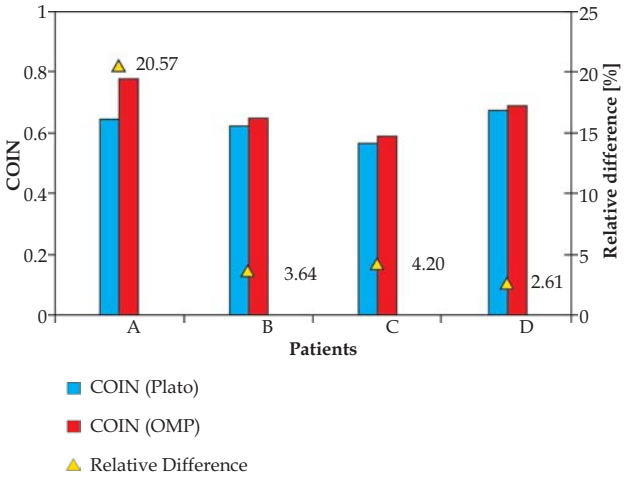



**Fig. 8.** Conformal index, COIN, calculated for each treatment plan planned in Plato and OB, using the IPSA algorithm

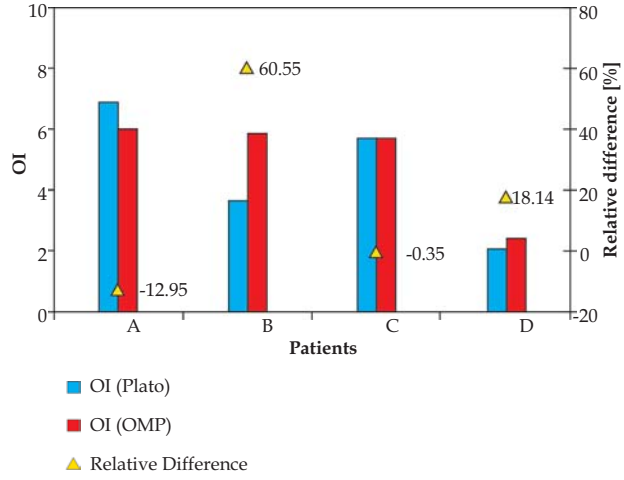



**Fig. 9.** Overdosage index, OI, calculated for each treatment plan planned in Plato and OB, using the IPSA algorithm

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