

Quality assurance procedures during commissioning of a treatment planning system as a tool to establish new standards before migration

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Abstract

Purpose: Treatment planning system commissioning is one of the most important parts of the quality assurance system in a working brachytherapy department. Migration to a more sophisticated system is always a step forward for the planning team but careful verification of the workflow and obtained results is mandatory. The question is not only whether the quality and safety of the previous standards can be preserved, but also about the possibility of reaching a higher level. The general objective of this study was to compare and verify calculation algorithms implemented in the treatment planning systems Plato Brachytherapy v.14.3.7 and Oncentra Masterplan (Brachy) V.3.1 SP 3.

Material and methods: In order to revise the optimization algorithms implemented in the compared treatment systems, a series of 20 interstitial breast cancer applications were used. Treatment plans were optimized using geometric optimization with distance option. The parameters V, D90, D100, V100, V150, V200 and DNR were gained for target volume. On the basis of the value of Student's t-test parameters ($\alpha = 0.05$) plans prepared using optimization algorithms implemented in the two treatment planning systems were compared.

Results: For the treatment plans prepared using Oncentra Masterplan a lower value of DNR ($p = 0.018$) was obtained. Uniformity of the dose distribution does not collide with comparable D90 values for both treatment planning systems ($p = 0.109$). Dose throughout the target volume (D100) was also proved to be higher in plans prepared using Oncentra Masterplan ($p = 0.012$).

Conclusions: For interstitial applications Oncentra Masterplan planning system enables one to prepare a more homogeneous dose distribution but also a higher dose in the whole treated volume, while the volume covered with the therapeutic dose does not statistically differ.

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Purpose

The process of optimization of dose distribution is well recognized as one of the most important parts of the whole treatment planning procedure in modern brachytherapy. Thus the implemented optimization routines are essential modules of almost all clinically used treatment planning systems. Especially when high dose rate brachytherapy is used, minimal alteration of a single dwell time could result in the need for major modification of the whole treatment plan. Nowadays it is almost impossible to prepare an acceptable treatment plan in a reasonable time by entering dwell times manually. In order to achieve the best treatment outcome optimization algorithms are consequently developed and verified. When the catheter reconstruction is performed very precisely using 3D imaging methods – including US, CT and MRI – it is essential to preserve high

quality of the whole procedure by using trusted dose calculation and optimization algorithms [1-3]. Treatment planning system commissioning is one of the most important parts of the quality assurance system in a working brachytherapy department. Migration to a more sophisticated system is always a step forward for the planning team but careful verification of the workflow and obtained results is mandatory [4]. The question is not only whether the quality and safety of the previous standards can be preserved, but also about the possibility of reaching a higher level. The general objective of this study was to compare and verify calculation algorithms implemented in the treatment planning systems Plato Brachytherapy v.14.3.7 and Oncentra MasterPlan (Brachy Planning) V.3.1 SP 3. The discussed procedure was a part of commissioning of the Brachy Planning module before migration from the Plato system.

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Material and methods

In order to compare calculation and optimization algorithms implemented in Oncentra Masterplan (OMP) and Plato Brachytherapy (PLATO) treatment plans for 20 multiplane interstitial HDR breast implantations were prepared [5, 6] (Fig. 1).

For reconstruction of the catheter geometry and definition of the tumour bed area, CT images were used with 3 mm slice thickness. To avoid inconsistencies concerning delineation of the target, the clinical target volume (CTV) was reconstructed only once in the target definition module of Oncentra MasterPlan and exported as a DICOM RT file to the PLATO system [7].

Before the export procedure the target structure was simplified and the number of vertices was reduced to 50 to avoid errors in the PLATO import module (the older system does not accept contours that are too detailed – 99 points is the high limit).

To ensure that there were no differences concerning the CTV volume Student's t-test for related variables ($\alpha = 0.05$) was performed. Implant geometry (catheters) was reconstructed by one physicist using both treatment planning systems to minimize the observer-related catheter reconstruction deviation.

After reconstruction of the catheter geometry, only dwell positions inside the CTV were activated [8]. For the Oncentra MasterPlan the dose was prescribed at the 50 dose points located at the surface of the CTV. For the PLATO system points were located at 8 millimetres distance from each other. Optimization at dose points with the distant option were used in both planning systems, as this optimization technique was most commonly used in the Greater Poland Cancer Centre Brachytherapy Department [9-11].

For verification and comparison of obtained dose distributions the authors decided to use commonly known parameters: D90, D100, V100, V150, V200 and DNR (dose

non-uniformity ratio). Only the CTV volumes were used as absolute values (ccm) [7, 12].

D90 and D100 were calculated as the dose deposited in 90 and 100 percent of the CTV volume respectively. V100, V150 and V200 were calculated as the percentage fraction of CTV where the deposited dose was 100, 150 and 200 percent of the prescribed dose respectively. All the parameters were compared using Student's t-test for related variables ($\alpha = 0.05$).

No manual correction of the dose distribution was performed as the main aim of the study was to compare parameters obtained using implemented algorithms [9-11].

Results

Mean values of CTV volume calculated in PLATO and OMP were 49.72 ccm and SD was 21.79 for both treatment planning systems. The assumption based on results of statistical analysis is that there were no statistically significant differences between CTV volume calculated using PLATO and OMP.

No statistically significant differences ($p = 0.68$) concerning volume receiving 100% of the prescribed dose was noted. Mean value of V100 was $76.06 \pm 7.42\%$ for PLATO and $76.60 \pm 5.67\%$ for OMP. For the high dose area parameters mean values of V150 were $31.17 \pm 9.46\%$ for PLATO, and $28.87 \pm 8.54\%$ for OMP. The observed V200 values were $12.67 \pm 3.28\%$ for PLATO and $11.97 \pm 2.91\%$ for OMP respectively. There were no statistically significant differences observed ($p = 0.08$) between calculated values. Calculated volume of the CTV (CTV VOL) and V100, V150, V200 parameters and results of the data analysis are presented in Table 1 and Fig. 2.

Statistical differences between the D90 parameter calculated in both planning systems were not significant either – $81.20 \pm 7.85\%$ for PLATO and $83.21 \pm 6.86\%$ for

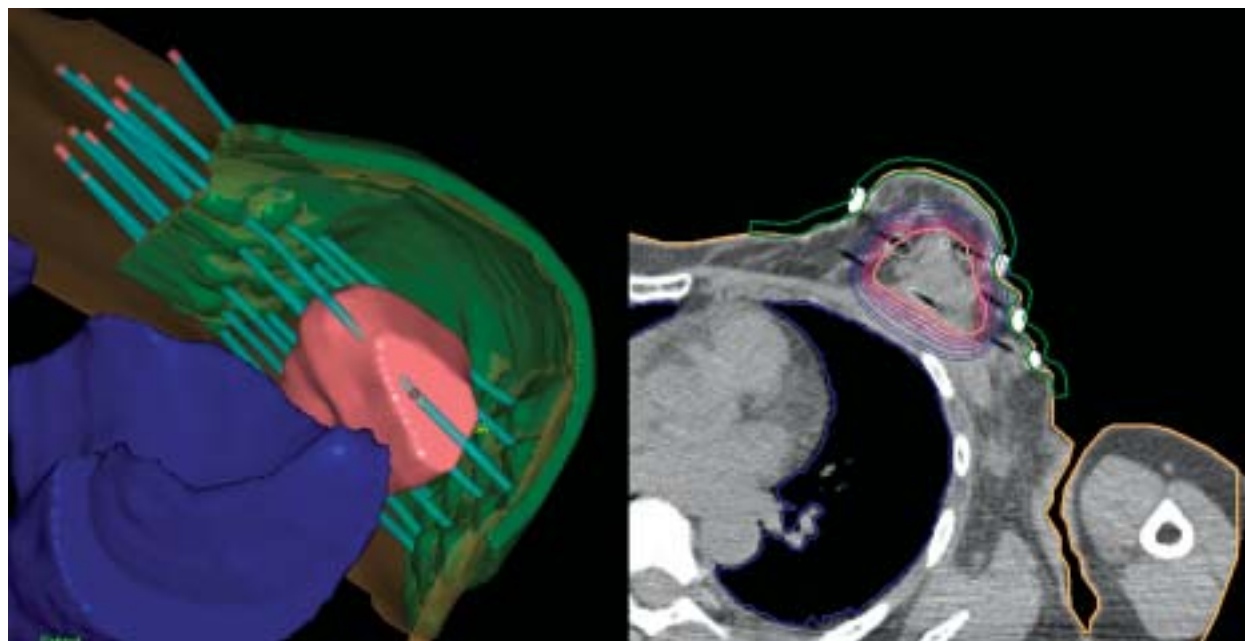
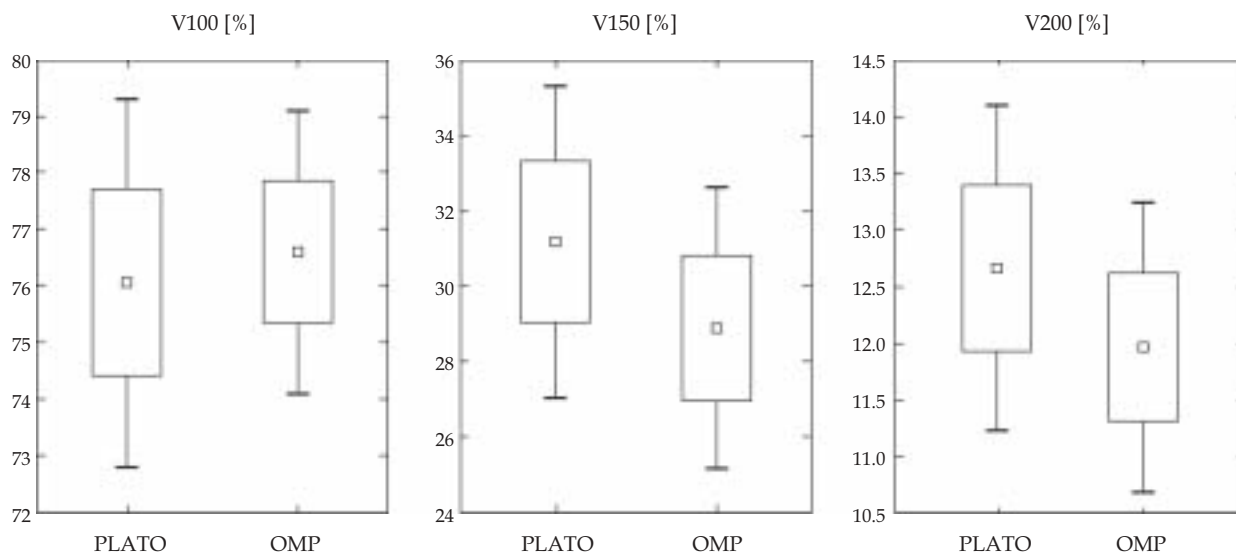


Fig. 1. Reconstructed geometry of the application and sample dose distribution for multiplane HDR breast implant

Table 1. Calculated volume of the CTV and dose distribution parameters for both used treatment planning systems

Plan no.	CTV VOL [ccm]		V100 [%]		V150 [%]		V200 [%]	
	PLATO	OMP	PLATO	OMP	PLATO	OMP	PLATO	OMP
1	86.50	86.50	80.92	77.10	28.55	23.07	10.22	8.66
2	61.80	61.80	78.32	85.32	25.08	27.70	10.18	10.99
3	41.90	41.90	77.33	77.98	28.88	23.87	12.17	11.36
4	40.90	40.90	72.13	68.19	27.38	20.47	11.61	9.73
5	25.60	25.60	76.17	81.38	35.27	41.71	13.59	15.55
6	40.00	40.00	73.00	75.53	24.83	22.52	11.35	10.83
7	80.20	80.20	75.94	78.21	33.17	30.26	13.47	12.20
8	52.70	52.70	80.65	81.11	25.81	27.96	11.31	12.05
9	20.40	20.40	55.88	66.55	16.27	18.42	8.33	9.17
10	42.80	42.80	87.15	79.20	28.04	22.64	12.17	10.13
11	67.10	67.10	78.24	82.05	27.72	29.71	10.09	10.82
12	42.80	42.80	79.44	80.57	39.95	35.32	13.08	12.09
13	49.00	49.00	75.10	80.84	24.69	29.21	11.10	12.33
14	32.50	32.50	74.77	69.69	33.54	26.21	13.38	11.44
15	25.70	25.70	73.54	67.38	22.33	19.80	11.05	9.74
16	33.30	33.30	80.18	70.59	39.34	21.25	14.32	9.87
17	48.30	48.30	82.82	81.70	46.58	41.45	19.81	18.41
18	101.00	101.00	79.31	78.00	47.52	45.95	21.39	20.01
19	31.80	31.80	58.49	70.64	18.24	25.24	8.90	11.24
20	70.10	70.10	81.74	80.04	50.21	44.61	15.83	12.71
mean	49.72	49.72	76.06	76.60	31.17	28.87	12.67	11.97
SD	21.79	21.79	7.42	5.67	9.46	8.54	3.28	2.91
<i>p</i> value	1.00		0.68		0.09		0.08	

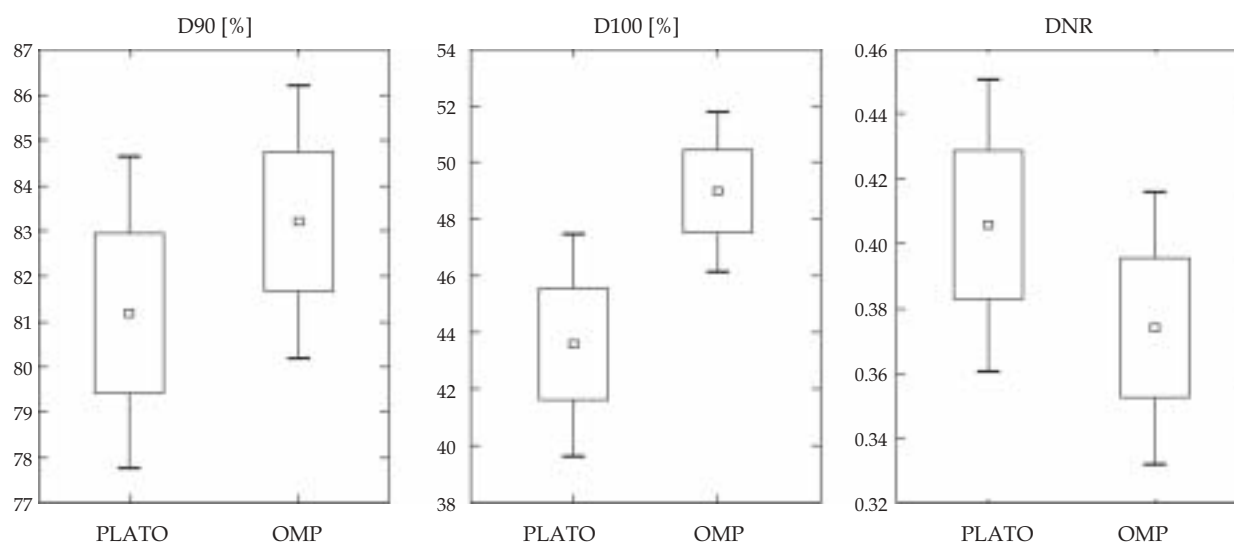
**Fig. 2.** Mean values and standard deviations for V100, V150 and V200 for both treatment planning systems

OMP ($p = 0.11$). Higher dose in the whole CTV volume typified plans prepared with OMP. Statistically significant differences were observed when comparing the calculated D100 parameter – $43.57 \pm 8.88\%$ for PLATO and $49.01 \pm 6.44\%$ for OMP ($p = 0.01$). The dose distribution was

more homogeneous for plans prepared with OMP. Obtained DNR values proved to be statistically different – 0.41 ± 0.10 for PLATO and 0.37 ± 0.10 for OMP ($p = 0.02$). Obtained values of D90, D100 and DNR with results of statistical analysis are presented in Table 2 and Fig. 2.

Table 2. Calculated values of D90, D100 and DNR with results of statistical analysis, for both treatment planning systems

Plan no.	D90 [%]		D100 [%]		DNR	
	PLATO	OMP	PLATO	OMP	PLATO	OMP
1	89.00	88.00	49.00	53.90	0.35	0.30
2	83.80	93.90	44.30	55.80	0.32	0.32
3	83.30	86.80	50.50	56.20	0.37	0.31
4	73.30	69.00	41.00	37.20	0.38	0.30
5	78.60	85.80	23.30	45.00	0.46	0.51
6	80.50	84.30	45.70	49.10	0.34	0.30
7	81.00	84.70	44.30	50.10	0.44	0.39
8	86.70	87.60	41.40	50.40	0.32	0.34
9	63.80	74.30	35.70	37.40	0.29	0.28
10	96.20	88.30	63.80	56.20	0.32	0.29
11	84.80	89.80	48.10	57.10	0.35	0.36
12	83.30	85.50	49.00	49.40	0.50	0.44
13	80.00	86.80	39.50	46.10	0.33	0.36
14	77.60	70.80	48.10	39.90	0.45	0.38
15	78.60	76.60	42.90	40.30	0.30	0.29
16	81.90	80.90	25.70	54.20	0.49	0.30
17	90.00	89.80	44.30	54.70	0.56	0.51
18	83.80	83.70	45.70	48.30	0.60	0.59
19	62.90	73.30	37.10	45.60	0.31	0.36
20	84.80	84.20	51.90	53.20	0.61	0.56
mean	81.20	83.21	43.57	49.01	0.41	0.37
SD	7.85	6.86	8.88	6.44	0.10	0.10
<i>p</i> value	0.11		0.01		0.02	

**Fig. 3.** Mean values and standard deviations for D90, D100 and DNR for both treatment planning systems

Discussion

No observed differences among CTV volume, V100, V150, V200 and D90 suggest that Plato Brachytherapy and Oncentra Masterplan could be used interchangeably in

clinical practice. On the other hand, this study shows that the dose rate is more homogeneous for plans prepared with OMP ($p = 0.02$). That suggests that there should be differences among V100 and V150 ($DNR = V150/V100$) [12]. However, there are no statistically significant diffe-

rences concerning these parameters. A closer look reveals that the difference in V150 between plans prepared with OMP and PLATO is close to statistical significance ($p = 0.09$). A trial on a larger group of patients should dispel all doubts. Furthermore, the dose distributed to the whole CTV volume is higher in plans prepared using OMP. Probably it is also possible to achieve an identical dwell position/time pattern for both treatment planning systems, but the aim of this study was to compare and verify the obtained results and to check whether the dose distributions are clinically acceptable.

Conclusions

Dose distributions for the multiplane HDR breast implants, calculated using optimization algorithms implemented in Oncentra MasterPlan (Brachy Planning), are faultless from the physicist's point of view. Obtained results are also clinically acceptable and most of the parameters do not differ significantly from those calculated using the trusted PLATO system.

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