A Comprehensive Patient Specific Quality Assurance Scheme Developed for Naso-pharynx Brachytherapy

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INTRODUCTION:

PURPOSE: To verify the radiation dose delivery to potential point of interests, a comprehensive Patient Specific Quality Assurance (PSQA) approach was established for brachytherapy.

MOTIVATION: In radiation therapy, accurate and precise dose delivery to the tumor can be directly assessed through treatment outcomes like quantitative parameters applied for tumor control and sparing normal tissues. The current study is an effort for development and clinical implementation of a Patient Specific Quality Assurance (PSQA) plan for nasopharyngeal cancers treated using a HDR brachytherapy equipped by a Co-60 source.

MATERAILS: EBT3 Gafchromic film (Ashland Specialty Ingredients, Bridgewater, NJ, USA) was used to experimental dosimetry. These types of films, recommended for dosimetry, are known as low dependency on beam energy, and an excellent resolution. A remote afterload HDR brachytherapy system with a Co-60 source (Eckert & Ziegler, Bebig GmbH, Germany), equipped with the nasopharyngeal applicator (Rotterdam Type, Nucletron, Netherland). The Co-60 source encapsulated with 0.5 mm thick stainless steel and 1.5 mm in diameter borosilican active core were applied for irradiation (Eckert & Ziegler BEBIG GmbH, Germany). HDR PLUS system (Netherland) was utilized as brachytherapy treatment planning system. This TPS calculates the dose using AAPM TG-43 algorithm. 64-slice CT scanner (General Electric Medical Systems, USA) was used to make patient and phantom tomographic imaging.

METHODS: Two home-made Head and Neck (H&N) phantoms were designed and evaluated for PSQA tasks in Brachytherapy. Radiation dose distribution was originally measured at several potential positions using EBT3 Gaf-chromic films. Using a three-dimensional (3D) radiation dose distribution data acquired via a back-projection technique, the measured dose distribution was then extended for several region of interests (ROIs) including target volumes (TVs) and Organ at Risks (OARs). The results achieved were then compared with those computed using a Treatment Planning System (TPS) at the corresponding conditions. Both dataset acquired through measurements and computation, were ultimately compared with those calculated correspondingly through a Monte Carlo based simulation which is known as the gold standard of dose verification. The results were then assessed using gamma function algorithm with routine pass criteria (3%/3mm) applied for EBRT techniques.

RESULTS:

TPS positioning and magnification assessment in BALTAS Phantom

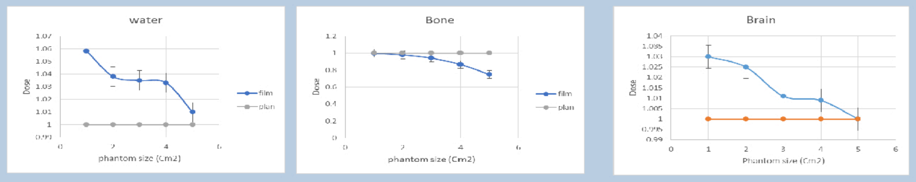
At this stage, the distance between the spherical markers and the position of these markers relative in the phantom was measured and matched with reality (Table 1).

Table 1: comparison of TPS results to positioning and magnification test

	Spherical markers distance in different rows (cm)				
	1	**2**	**3**	**4**	**5**
Reality spherical distance in phantom	2	2	2	2	2
Spherical distance in TPS	2.01	2.02	2.02	2.00	2.01

Evaluation of the TPS accuracy in cubic Phantom

At this stage, accuracy of TPS film dosimetry was assessed in different cubic phantoms (1*1to 5*5 and mentioned materials), that shown in figure 1.



(A) (B) (C)

Figure 1: Evaluation of TPS film dosimetry accuracy in cubic phantom contain A) Water/ soft tissue, B) K_2HPO_4 as bone tissue and C) Nitric acid as brain tissue, at different sizes.

β factor to provide accuracy of QA dosimetry

As seen in Table 2, the soft tissue and near the source have minimum and maximum β-factor respectively through the equation:

$$D_0 = \beta D e^{+\sum_{i=1}^{n} \mu_i t_i}$$

Table 2: Nasopharyngeal phantom β-factors

Measurement points	Distance to skin (cm)	Position	β-factor
1	7.86	Soft tissue	0.05
2	5.84	Soft tissue	0.6
4	5.23	Near the source	3.19
5	7.68	Near the source	3.22
6	5.3	Near the source	3.1
7	3	Behind low density bone	1.34
8	1.9	Behind the teeth	0.82
9	2.56	Behind the teeth	0.99
10	3.07	Behind low density bone	1.17

As it is shown in Table 2, Location inside the soft tissue and near the source have minimum and maximum β-factor respectively.

Dose alternation on the horizontal axis

Table 3 presents dose deference data, with measurement points shown in Figure 2.

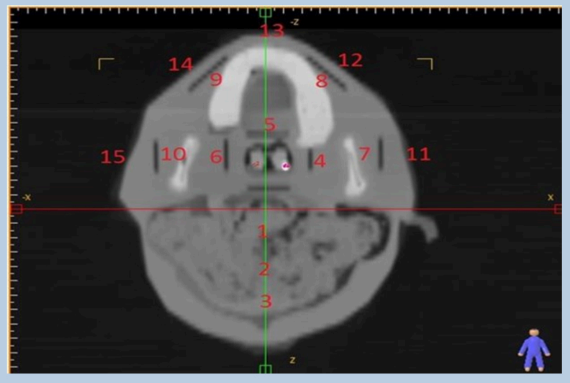


Figure 2: Measurement points in nasopharyngeal patients

Table 3: Comparison of PSQA process associated by β-factor with nasopharyngeal patient TPS results.

Measure-ment point number	β-factor	(PSQA/Plan Dose) (%)				
		patient 1	patient 2	patient 3	patient 4	patient 5
4	3.19	2.6	4.6	4.2	3.8	4.2
5	3.22	2.4	3.1	5.8	4.1	4.9
6	3.1	2.8	3.5	4.6	3	3.8
7	1.34	1.2	1	1.3	2.6	0.5
8	0.82	2.8	4	6	4.3	2.5
9	0.99	1.9	3.2	5.7	4.2	2.2
10	1.17	1.4	1.5	2.5	1.6	1.7

The maximum dose difference between film, and TPS were found to be 6.1%, Gamma pass rates with 3%/ 3 mm for measured, calculated and simulated for a 3D dose distribution were found 93%, 90.3% and 91.7% respectively. The gamma pass rates were also evaluated with 4%/ 2 mm criteria to achieve the results of more than 90% as safe pass rate.

CONCLUSION:

Although the uncertainty in dose calculation is considered, there is still an opportunity to increase the precision of the dose delivery through a PSQA program. The application of gamma index instead of point dose reports is recommended for brachytherapy. The precision and accuracy of dose delivery can be increased by the evaluation of the dose distribution and understanding of the treatment planning limits through a PSQA plan.

REFERENCES: Gholami, M.H., Mohammadi, M., Jaberi, R. and Sedighi, A., 2018. A Specific Patient Quality Assurance (PSQA) procedure for a Co-60 source based High Dose Rate Brachytherapy. *Iranian Journal of Medical Physics*, *15*(Special Issue-12th. Iranian Congress of Medical Physics), pp.21-21.