SURVEY OF EQUIPMENT QUALITY CONTROL IN RADIOTHERAPY CENTERS IN CROATIA: FIRST RESULTS

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INTRODUCTION

Implementation of advanced radiation therapy techniques into clinical practice has a paramount influence on tumour control as well as normal tissue sparing. Introduction of Conformal Radiation Therapy (CRT) and Intensity Modulated Radiation Therapy (IMRT) into clinical practice results in precise 'tailoring' of dose distributions and according to that in reduction of irradiated volumes. This is not possible without, for the application of advanced radiation therapy techniques constructed, linear accelerators. These accelerators must be very precise, well tuned and maintained. In this way the milestone of radiation therapy quality assurance programme is machine quality control (QC).

First step in development of quality control programme is existence of written QC protocols. The survey of existence of written QC protocols showed the lack of written protocols for QC procedures in Croatian radiotherapy departments [1]. In this way regular implementation of the procedures are usually left to the conscience of the medical physicists. In the IAEA granted projects CRO6008 and RER9093, we harmonized existing QC protocols between radiation therapy departments at University hospitals Rijeka and Osijek and developed the new ones. The protocols made according to international guidelines [2–4] are publicly available at websites of the State Office for Radiological and Nuclear Safety [5] and Croatian medical physics society in order to help other radiotherapy departments in Croatia to develop their own ones.

Next step was reviewing of QC practices in different centres and exchanging experiences. For that purpose we defined a set of tests, according to the existing QC protocols. Then, on-site measurements were done to check QC parameters of linear accelerators and simulators in six radiation therapy centres in Croatia. In this paper we present the tests preformed, devices and analysing tools used, along with the overall results.

MATERIALS AND METHODS

Tests were preformed in six radiotherapy centres in Croatia (3 in Zagreb, 1 in Split, Osijek and Rijeka), on nine linear accelerators and six simulators. Procedures for respective tests were extracted from written and well established QA/QC protocols of University hospital Rijeka and University hospital Osijek. The following tests were performed:

Table 1. Tests performed on linear accelerators

TEST	CRITERION	TOLERANCE
optical distance indicator	mech. acc.*	2 mm
field size indicators	mech. acc.*	2 mm on each edge
crosshair intersection stability with collimator rotation	mech. acc.*	radius 1 mm
laser alignment with isocenter	mech. acc.*	2 mm
light/radiation coincidence (symmetric and asymmetric fields)	rad. acc.**	2 mm on edges; 1 mm on central axis
collimator rotation	rad. acc.**	2 mm
gantry rotation	rad. acc.**	2 mm
treatment couch rotation	rad. acc.**	2 mm
leaf positions with MLC (multileaf collimator)	rad. acc.**	2 mm
symmetry/flatness	rad. acc.**	± 5 %
flat panel parameters	rad. acc.**	vendor specifications for caution and reject level

* mechanical accuracy
** radiation accuracy

Tests were performed using tools which are regularly used in performance of our periodic QC routines. In this way we used the mechanical distance indicator, multi-purpose precision alignment device Iso-Align (Civco), constancy check device of all essential beam parameters QuickCheck Webline (PTW), QC3 and FC-2 phantoms and PIPSPro programme package for the checks of portal imaging device parameters [6], and X-Omat V (Kodak) radiographic films, DosimetryPro scanner (Vidar) and Coherence Physicist WS (Siemens) for radiation accuracy tests. Some tests were not preformed on all machines since some of the accelerators are old and not equipped with multileaf collimators or electronic portal devices.

Conventional simulators are also important part of radiotherapy equipment. They are used to simulate geometrical parameters of a treatment machine such as the gantry or collimator angle, field size, etc., and therefore have to be equal by its characteristics. Several measurements were done on six simulators, some of them testing mechanical and some, the radiation accuracy. Following tests were performed:

Table 2. Tests performed on conventional simulators

TEST	CRITERION	TOLERANCE
field size indicator	mechanical accuracy	2 mm
crosshair intersection stability	mechanical accuracy	2 mm
laser alignment with isocenter	mechanical accuracy	2 mm
light/radiation coincidence	radiation accuracy	2 mm
collimator rotation	radiation accuracy	2 mm

RESULTS

For the purpose of this work we collected a large number of data which were statistically analyzed. It showed a great variety in values regarding parameters which were tested.

First, we investigated the mechanical and geometrical characteristics of linear accelerators. The precision of optical distance indicator (ODI), lasers, crosshair intersection stability with collimator rotation and field size are showed in Figure 1.

Regarding mechanical accuracy of the machines, results showed that crosshair intersection stability with collimator rotation was most frequently out of tolerance. Namely, 22.2 n % of values are larger then 2 mm. Other values are mainly in tolerance.

Analysis of tests used to check radiation accuracy showed that rotation of treatment couch and gantry was troublesome. Over 20 % of the values obtained with these tests were over 2 mm (Figure 2a). Also, machines equipped with a multileaf collimator have 25 % out – of – tolerance values for width of stripes in MLC grid test [5] (Figure 2b). Results are also divided in two categories within tolerance values having in mind that values between 1 – 2 mm are already a caution level.

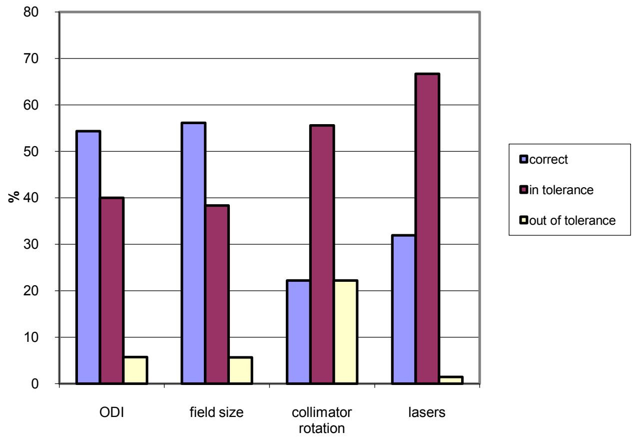

Figure 1. Mechanical accuracy

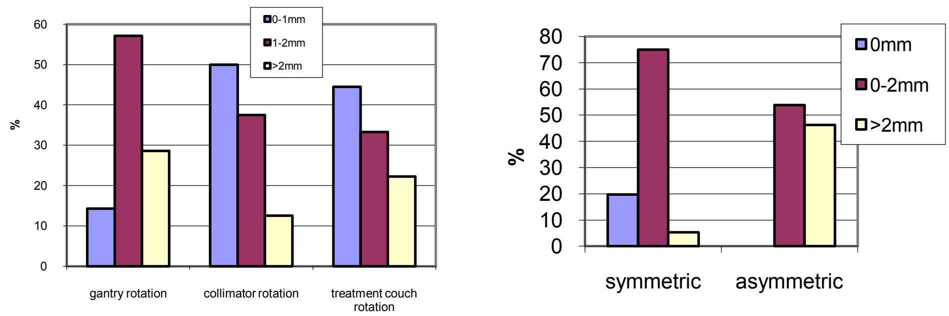

Figure 2. a) Radiation accuracy, b) MLC parameters

The light/radiation coincidence in symmetric and asymmetric fields is presented in Figure 3.

The light/radiation coincidence in symmetric and especially asymmetric fields is an important test due to frequent use of half-fields in radiotherapy (opposed tangential fields technique for breast cancer, ConPass technique for head and neck cancer). Overlapping or distinction in asymmetric fields can result in non-precise dose delivery therefore causing damage of organs at risk or low tumor control. Therefore, 46.2 % of out – of – tolerance values on central axis for asymmetric fields seem to be quite significant. The values for symmetric fields are mostly in tolerance.

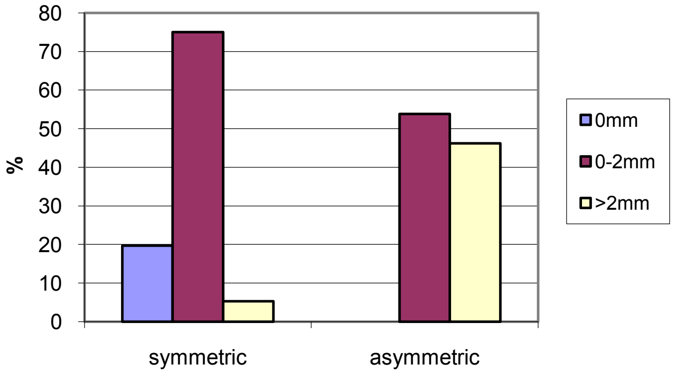

Figure 3. Light/radiation coincidence

Flatness and symmetry were checked using PTW QuickCheck Webline system for both photons (on two different depths) and electrons. Since the accuracy of this system is lower then checking radiation parameters in water phantom, tolerance values are increased a bit. Results are presented in Figure 4.

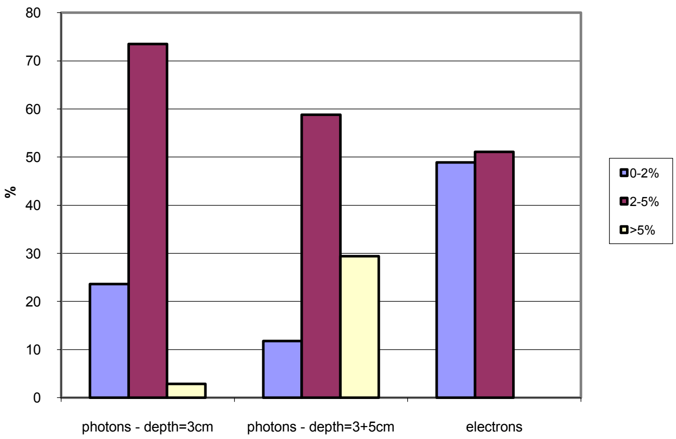

Figure 4. Flatness

Results showed great stability in symmetry value but also some out-of-tolerance values for flatness, especially for measurements for photons on larger depth. Namely, 29.4 % of measurements showed flatness greater then 5 % (Figure 4).

Some linear accelerators in Croatia (five of nine) are equipped with the system for portal imaging. Unfortunately, only two of them were suitable for measurements at the time of our collection of data. Tested parameters were resolution f_{50}, f_{40}, f_{30}, contrast to noise ratio (CNR), noise, field size and central axis deviation. Measured values were highly in tolerance.

Measurements performed on simulators (Table 2) showed that all values were in tolerance except for the laser alignment which showed out-of-tolerance values in 8.3 % of cases.

These results were expected since radiotherapy equipment for QC is still not recognized as an important issue from some hospitals management. Therefore, existence of equipment for QC is more exception than rule and written QC protocols do not exists in more than half Croatian radiotherapy departments [1].

CONCLUSION

Quality assurance of radiotherapy machines is essential in reducing uncertainties and errors in whole radiotherapy procedure. Upgrading the QA/QC in radiotherapy departments in Croatia is an ongoing process. Large improvements can be seen especially now because lot of new, very sophisticated equipment has been acquired recently. We proposed a unique QA manual that can be used for this equipment in whole Croatia. Measurements shown in this paper were used for sharing experience with medical physicists working at radiotherapy departments in Croatia. If, at least, similar QC protocols were used in Croatia, it would be possible to do the intercomparison of results among the different centres. This is necessary for clinical trials and also for sharing clinical radiotherapy experience and transferring it between centres [7]. The work, presented in this paper, is an effort in establishing uniformity in quality assurance programmes among radiotherapy centres in Croatia, especially since the equipment is very similar in these six locations.

LITERATURE

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