



Innovative Non-Irradiating and Non-Invasive Per Fraction Control System in Radiotherapy: Surface-Guided Radiation Therapy Experience of Casablanca Cancer Center

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Abstract

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AIM: Evaluation of the added value of radiotherapy guided by the cutaneous surface in the positioning and monitoring of the radiotherapy session.

PATIENTS AND METHODS: This study included 21 consecutive patients treated with an accelerator dedicated to "True Beam[®] stereotactic radiotherapy whose sessions were monitored by an Optical Surface Monitoring System: "(OSMS)[®]." We excluded from our study all treatments controlled exclusively by radiological imaging (IGRT). Positioning variabilities were compared between conventional imaging and skin surface infrared (OSMS) monitoring. Conventional imaging was in the form of standard radiography (KV) performed during the treatment session or three-dimensional by a series of cone-beam computerized tomography scanned images made at the beginning and end of treatment. The total time of the session and the positioning variability's in the three planes were reported.

RESULTS: The results of our study show that the cutaneous surface monitoring allowed to obtain a faster alignment of the patient with an improvement in the overall time of the session with a mean at 32% (14.5–49.27%), likewise a sub-millimeter positioning quality for all locations with a median longitudinal distance of 0.02 mm (0–0.4), 0.02 mm verticality (0–3.5), and laterality 0.02 mm (0–0.87). This benefit is significantly greater for cerebral and head-and-neck's localizations.

CONCLUSION: OSMS[®] is a non-invasive and non-irradiating means that allow reliable and fast irradiation.

Introduction

Skin surface-guided radiotherapy (SGRT) is a relatively a new technique of radiotherapy which allows both precise positioning of patients and real-time monitoring of any possible movement during radiation delivery, based on the skin surface [1]. Indeed, SGRT is a non-invasive and non-irradiating technique because it uses infrared light detected by cameras placed in the treatment room to determine the position of the patient's skin surface. This would allow, first, precise initial positioning of the patient than the use of tattoo points alone, second, once their radiation is triggered this non-invasive system would ensure a follow-up of the patient's movements throughout the session, and finally, if the tolerance threshold of intrafractional movements is exceeded, an instantaneous stop of the irradiation beam takes place which allows an extremely safe irradiation [2]. To evaluate the added value of this new tool in practice, an observational study was carried out within our department, which involved 21 consecutive

patients treated by a new generation line gas pedal dedicated to stereotaxis "True Beam Stx[®]" which is equipped with on-board imaging and an optical surface monitoring system (OSMS) [3]. The study consisted in a comparative analysis of the motion variability in the different spatial planes between conventional two-dimensional (Kv) and/or three-dimensional (cone beam computerized tomography [CBCT]) images and the OSMS[®] surface monitoring data.

Patients and Methods

This is a descriptive retrospective study carried out at the Casablanca Cancer Center, which involved 21 consecutive patients treated with a gas pedal (True Beam Stx), at total of 141 radiotherapy sessions were analyzed (Table 1). The OSMS used in the study is Varian's OSMS[®], which uses bright light projected on the patient to determine the position of a region

Table 1: Summary table of the main characteristics of patients and variations in their positioning in the three spatial planes

	Irradiation site	Total of images	Variation in longitudinal axis Médian (Min–Max)	Variation in vertical axis Médian (Min–Max)	Variation in lateral axis Médian (Min–Max)
Case 1	Brain (lung metastasis)	3	0 (0.01–0.05)	0.03 (0.02–0.11)	0.03 (0.02–0.05)
Case 2	Brain (glioblastoma)	28	0.2 (0.17–0.22)	0.06 (0.03–0.31)	0.08 (0.01–0.32)
Case 3	Head and neck	8	0.01 (0–0.37)	0.35 (0–5.16)	0.87 (0–4.23)
Case 4	*re-irradiation (medulloblastoma)	4	0 (0–0.01)	0.005 (0–0.03)	0.01 (0–0.02)
Case 5	Brain (rectal metastasis)	3	0.01 (0–0.12)	0.01 (0–0.13)	0.01 (0–0.07)
Case 6	Brain (lung metastasis)	3	0.01 (0–0.01)	0 (0–0.02)	0 (0–0)
Case 7	Brain (lung metastasis)	3	0 (0–0.02)	0 (0–0.09)	0.02 (0–0.04)
Case 8	Brain* (pineocytoma)	4	0.035 (0–8)	0.045 (0.01–11.78)	0.05 (0–5.19)
Case 9	Brain (breast metastasis)	5	0.01 (0–0.01)	0.02 (0.01–0.04)	0 (0–0.01)
Case 10	Brain* (breast metastasis)	2	0.405 (0.02–0.79)	1.1 (0.04–2.16)	0.565 (0.01–1.12)
Case 11	Brain (lung metastasis)	2	0 (0–0)	0.035 (0.01–0.06)	0.005 (0–0.01)
Case 12	Brain (breast metastasis)	4	0.005 (0–0.01)	0.02 (0.01–0.04)	0 (0–0.01)
Case 13	Vertebral metastasis	4	0.145 (0.03–0.46)	3.505 (0.02–8.09)	0.14 (0.09–0.21)
Case 14	Brain (colorectal metastasis)	7	0.02 (0–0.03)	0.04 (0–0.07)	0.01 (0–0.02)
Case 15	Head and neck	14	0.02 (0–2.81)	0.02 (0–1.64)	0.02 (0–0.6)
Case 16	Head and neck	31	0.03 (0–0.13)	0.02 (0–0.09)	0.01 (0–0.15)
Case 17	Head and neck*	4	0.03 (0.02–0.04)	0.025 (0.01–0.08)	0.025 (0–0.03)
Case 18	Brain* (glioblastoma)	3	0.03 (0.02–0.11)	0.06 (0.06–0.11)	0.04 (0.03–0.09)
Case 19	Vertebral metastasis	5	0.01 (0–5.82)	0.02 (0–7.32)	0.01 (0–5.71)
Case 20	Brain (metastasis)	3	0.03 (0.03–0.46)	0.04 (0.04–0.09)	0.17 (0.16–0.17)
Case 21	Brain (metastasis)	3	0.05 (0.01–0.07)	0 (0.09–0.02)	0.01 (0.01–0.02)

of interest on the patient’s surface [3]. In this study, the total session time and positioning variability were reported.

Positioning variability was compared between conventional imaging and infrared skin surface monitoring (OSMS®). Conventional imaging was in the form of either standard radiography (KV) performed during the treatment session or three-dimensional imaging by a CBCT [4].

Inclusion criteria

The following criteria were included in the study:

Patients treated with a gas pedal dedicated to stereotactic radiotherapy “True Beam®.”

- Monitoring by optical surface system “OSMS®.”
- Control by radiological imaging (image-guided radiation therapy [IGRT]).

Exclusion criteria

Treatments controlled exclusively by radiological imaging (IGRT).

Results

The variation of the positioning parameters in the three basic planes of space was inframillimetric with a median in longitudinally of 0.02 mm (0–0.4), in verticality 0.02 mm (0–3.5 mm), and in laterality 0.02 mm (0–0.87) (Figures 1-3), While the median of the variations in rotational movements were <0.5°. Skin surface monitoring resulted in faster patient alignment with a significant gain in overall session time, with a median gain of 32%.

Discussion

Radiotherapy is a major therapeutic weapon in oncology. It has made great strides forward, allowing for more precise treatment that better targets tumor volumes and spares as many healthy neighboring organs as possible [5]. Indeed, the area of conventional two-dimensional radiotherapy based on bone markers has given way to conformal radiotherapy using three-dimensional imaging and thus irradiation of volumes. Subsequently, the computer revolution made it possible to modulate the irradiation beam and gave birth to conformal radiotherapy with intensity modulation, which is not conceivable without three-dimensional imaging at the time of treatment, thus giving rise to IGRT [6].

Although IGRT allows a precise and safe irradiation, it exposes, on the one hand, to an additional dose of radiation and, on the other hand, does not take into account possible intrafraction movements [7]. SGRT, which is a non-invasive and above all non-irradiating tool, is part of the innovative trajectory of radiotherapy, essentially allowing monitoring of the patient’s movements during irradiation with the added advantage of instantaneous stopping of the irradiation beam if the movements exceed the authorized tolerance threshold, thus providing highly precise and extremely reliable irradiation [8]. To verify the added value of skin surface-guided radiotherapy in our practice, we analyzed 141 radiotherapy sessions by comparing the shifts obtained by the available “OSMS®” surface monitoring and the usual radiological images, either conventional (Kv) or three dimensional (CBCT). Wagner *et al.* [9] have demonstrated that during intracranial stereotactic radiotherapy, surface imaging allows to obtain an inframillimetric precision. Similarly, other team shave reported their experience [10], [11] with almost similar results between the use of a stereotactic frame and the window mask combined with an SGRT technique, with a concordance of about 1 mm/1°. The use of SGRT to treat intracranial lesions has led to its application

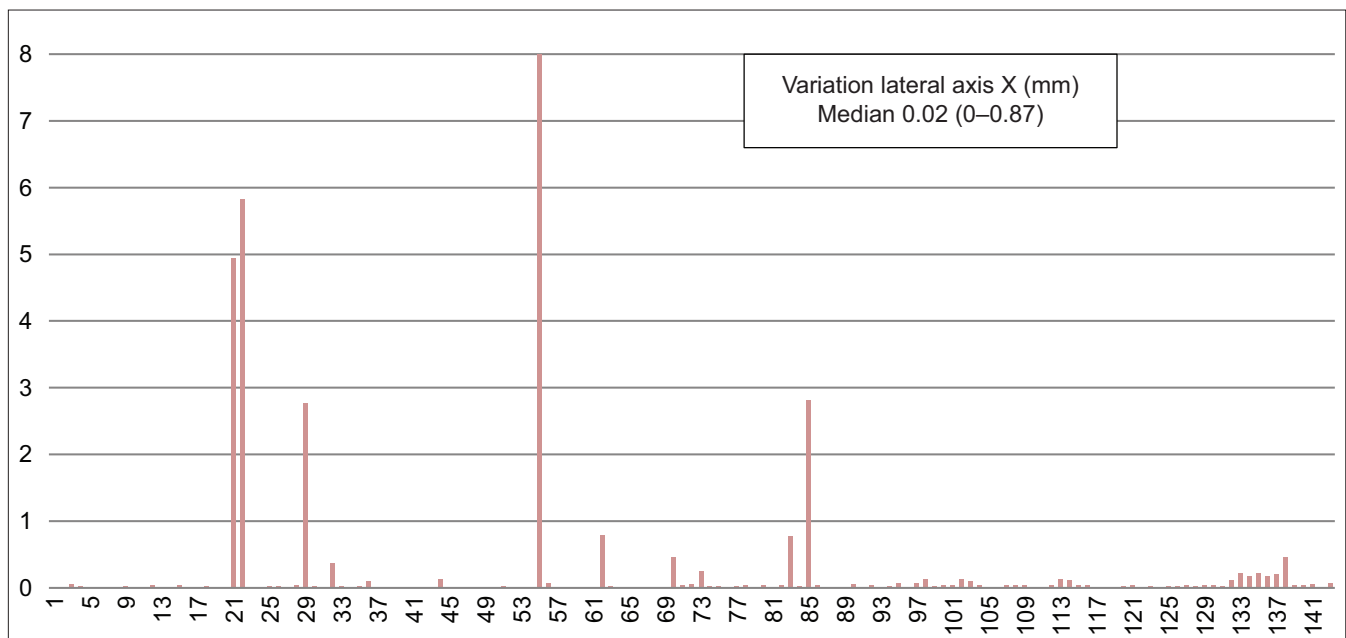


Figure 1: The variation of the positioning parameters in the lateral axis (x)

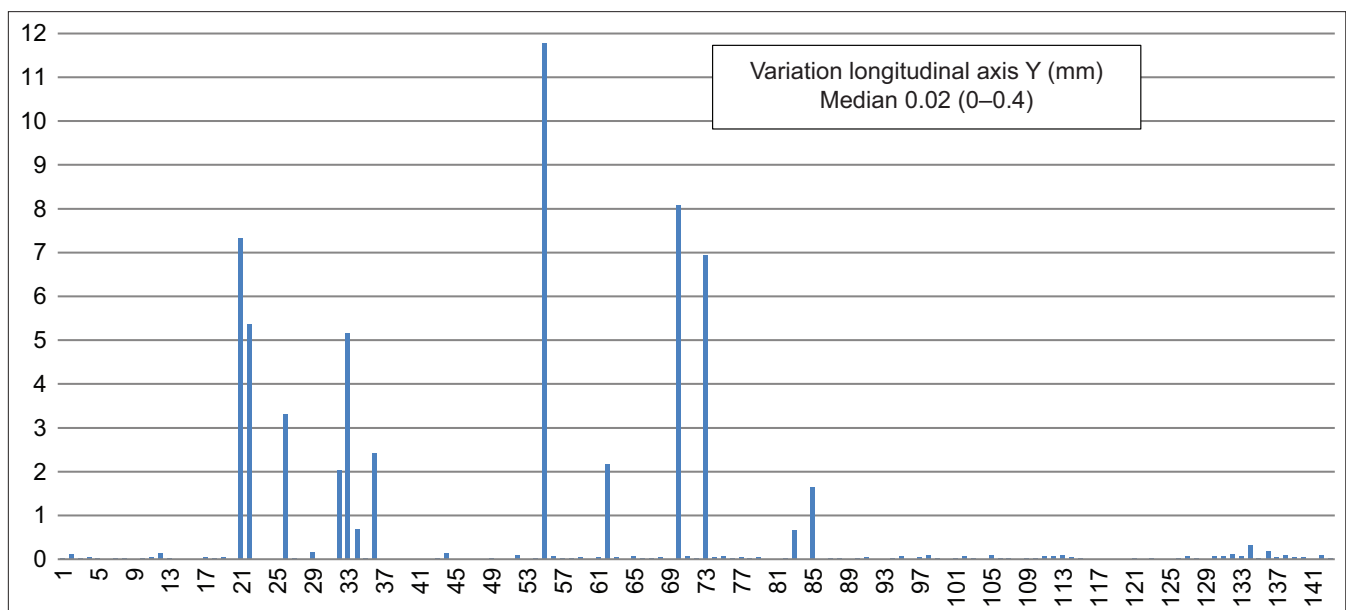


Figure 2: The variation of the positioning parameters in the longitudinal axis (y)

to the treatment of head-and-neck cancers [12]. It is usual, in case of otolaryngology irradiation, to make a thermoformed mask to immobilize patients. As SGRT requires direct visualization of the patient's skin, the use of a windowed mask is essential [13]. To ensure reproducibility of the treatment, Li *et al.* [14] demonstrated that an open mask offers immobility comparable to closed masks with movements with a mobility in the six planes of space of about 1 mm/1°. The results of our study agree with those of the literature with inframillimeter averages, all locations combined [15]. However, we have noted that the accuracy of surface monitoring is relatively poorer in extracranial locations [16]. This could be explained

by the respiratory movements that indirectly influence the position of the skin surface in both thoracic and abdominal-pelvic locations. Nevertheless, several studies [17], [18] have suggested that there is a correlation between internal movements and skin surface, which may reduce planning target volume margins and thus allow more targeted irradiation [19]. Furthermore, data from our study show that surface monitoring saves time in the treatment room [20] with a considerable reduction in the average session duration of 32% (14.5–49.27%). This time saving became even more important as the expertise of the manipulators increased.

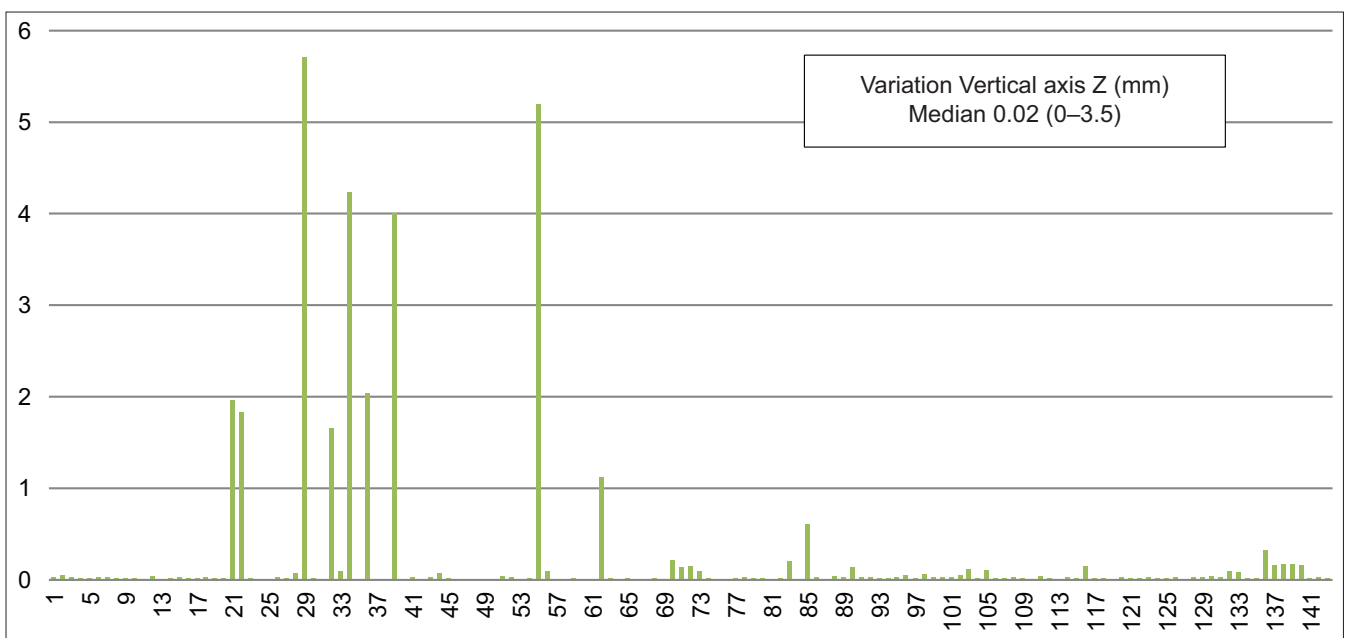


Figure 3: The variation of the positioning parameters in the vertical axis (z)

Conclusion

The optical surface monitoring system is a non-invasive and non-irradiating means, complementary to conventional IGRT means, which allows real-time intrafraction monitoring with instantaneous stop of the irradiation beam and thus reliable and fast irradiation [21].

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