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Research Article

A Pilot Study Evaluating the Effectiveness of Dual-Registration Image-Guided Radiotherapy in Patients with Oropharyngeal Cancer

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ABSTRACT

Purpose: The purpose of the article was to determine the impact of Dual Registration (DR) image-guided radiotherapy (IGRT) on clinical judgement and treatment delivery for patients with oropharyngeal cancer before implementation.

Methods: Ninety cone beam computed tomography images from 10 retrospective patients were matched using standard clipbox registration (SCR) and DR. Three IGRT specialist radiographers performed all registrations and evaluated by intraclass correlation to determine inter-rater agreement, Bland-Altman with 95% limits of agreement to determine differences between SCR and DR procedures, changes in clinical judgment, time taken to perform registrations, and radiographer satisfaction.

Results: Inter-rater agreement between radiographers using both SCR and DR was high (0.867 and 0.917, $P \leq .0001$). The 95% limits of agreement between SCR and DR procedures in the mediolateral, cranial–caudal, and ventrodorsal translational directions were −6.40 to +4.91, −7.49 to +6.05, and −7.00 to +5.44 mm, respectively. The mediolateral direction demonstrated significant proportional bias ($P \leq .001$) suggesting non-agreement between SCR and DR. Eighty percent of DR matches resulted in a change in clinical judgement to ensure maximum target coverage. Mean registration times for SCR and DR were 94 and 115 seconds, respectively, and radiographers found DR feasible and satisfactory.

Conclusion: The standard method using SCR in patients with oropharyngeal cancer underestimates the deviation in the lower neck. In these patients, DR is an effective IGRT tool to ensure target coverage of the inferior neck nodes and has demonstrated acceptability to radiotherapy clinical practice.

RÉSUMÉ

But : Déterminer l'incidence de la radiothérapie guidée par imagerie (IGRT) à double registration sur le jugement clinique et l'administration du traitement pour les patients avec un cancer oropharyngé avant la mise en œuvre.

Méthodologie : Quatre-vingt-dix images de TDM à faisceau conique ont été appariées en utilisant une registration « clipbox » standard (SCR) et la double registration. Trois radiographes spécialisés en radiothérapie guidée par imagerie ont effectué toutes les registrations et procédé à l'évaluation par corrélation intraclasse afin de déterminer l'accord entre les noteurs. Ils ont également utilisé les graphiques de Bland Altman avec une limite d'accord à 95% pour détecter les différences entre les méthodes SCR et DR, les changements dans le jugement clinique, le temps requis pour effectuer la registration et le degré de satisfaction du radiographe.

Résultats : L'accord entre les noteurs chez les radiographes qui utilisent les deux méthodes (SCR et DR) était élevé (0,867 et 0,917 $P \leq$ 0,0001). La limite d'accord à 95% entre les deux procédures dans les directions médiolatérales, crâniale caudale et ventrudorsale était respectivement de −6,40 à +4,91, −7,49 à +6,05 et −7,00 à +5,44 mm. La direction médiolatérales affichait un biais proportionnel significatif ($P \leq 0.001$), ce qui semble indiquer une absence d'accord entre les méthodes SCR et DR. Quatre-vingt pour cent des correspondances DR ont entraîné un changement de jugement clinique pour assurer une couverture maximale de la cible. Le temps de registration moyen pour les méthodes SCR et DR était respectivement de 94 et 115 secondes et les radiographes ont jugé la méthode DR faisable et satisfaisante.

Conclusion : La méthode standard utilisant l'approche SCR pour les patients avec un cancer oropharyngé sous-estime la déviation de la partie inférieure du cou. Pour ces patients, l'approche DR devient un outil IGRT efficace pour assurer la couverture de la cible pour les ganglions de la partie inférieure du cou, et son acceptabilité dans la pratique clinique de la radiothérapie a été démontrée.

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Introduction

Accurate localization of soft tissue volumes is vital for the effective delivery of radiotherapy in patients with oropharyngeal cancer. There have been many advances in image-guided radiotherapy (IGRT) [1], including cone beam computed tomography (CBCT). The practice of using CBCT for IGRT allows tumour volumes to be precisely localized and avoid healthy tissues [2,3]. This is important for patients receiving head and neck radiotherapy for primary and locoregional lymphatic nodal involvement because the inferior neck nodes can move independently of the primary tumour volume. Several studies have described and evaluated the problem of regional anatomical differences in the head and neck using megavoltage portal imaging [4–6], stereoscopic kilovoltage [7], CBCT [4, 8], and computed tomography (CT) on rails [9].

The problem of deviations in different regions of the head and neck is compounded by the increasing use of intensity-modulated radiotherapy techniques [10], which require CBCT scans to visualize soft tissues. It is common for commercial CBCT software packages to only allow for one region of interest (ROI) [1, 11], which inevitably encompasses a large volume comprising the primary cancer site, inferior regional neck nodes that may degrade the effectiveness of the image matching algorithm. Registering such a large ROI fails to accurately quantify larger setup errors in the inferior neck [4–9]. This could lead to a suboptimal treatment to the inferior neck nodes that may result in recurrence for the patient [10–13].

A study by van Beek et al [12] addressed this problem through the development of an automated multiple ROI algorithm for CBCT and tested their first clinical experience undertaken by radiographers. Radiographers found the multiple ROI easy to use with little additional workload and that it helped to identify patients for replanning [12]. This software is not commercially available for routine clinical use; however, Elekta Dual Registration (DR) is available [14]. DR allows the registration of two separate regions of anatomy, calculating their positional offsets independently, and proposing joint correction that best fit both ROIs. Manual corrections can be made to the proposed correction via applying a sliding-scale weighting to favour one ROI's over the other before applying the correction. Preset limits also alert the radiographer if a treatment target structure has moved closer to a critical structure [14]. In anatomical sites other than head and neck, Campbell et al [14] demonstrated in postprostatectomy patients that DR can be a more efficient registration, which could improve patient experience such as comfort [15] while also reducing interobserver variability. There is limited evidence to demonstrate the clinical impact and processes of using DR in head and neck patients. Therefore, the aim of this pilot study was to evaluate the impact of DR on clinical judgement and treatment delivery for patients with oropharyngeal cancer before clinical implementation.

Materials and Methods

A retrospective pilot study was planned and reported as per Standards of Quality Improvement Reporting Excellence (SQUIRE 2.0) guidelines [16]. The pilot study was considered a service evaluation by the Department of Clinical research at Taunton and Somerset NHS Foundation Trust following good clinical practice [17].

Patient Data

Ten retrospective patient CBCT datasets, a sample size recommended by Herzog [18] for pilot studies, who completed radiotherapy to an oropharyngeal primary and nodal area in 2015–2016, were anonymized.

Standard Procedures

Patients received their treatment supine immobilized in a Qfix Aquaplast (Avondale) nine-point thermoplastic immobilization mask covering head, neck, and shoulders. The mask is mounted on a Qfix Curve board, which itself was affixed and indexed to the Elekta iBEAM evo Couchtop. Patients were also tattooed on their sternum for mediolateral positional alignment. Radiographers followed a positioning protocol to ensure standardisation across patients [19]. CT planning scans were acquired using 2-mm slices (Philips Brilliance CT Big Bore CT simulator, Guildford, UK) planned using Pinnacle treatment planning system (Philips version 9.10). Before treatment, CBCT scans (XVI [5.02] 2016; Elekta AB Stockholm, Sweden) were acquired using 1-mm slices as per departmental protocol. This is justified by sampling theory which dictates that, in relation to slice thickness of scans, the ideal scenario is to sample at twice the rate of the resolution trying to achieve [20]. The CBCT preset selected was filter F0 and collimator S20 with a lens sparing gantry rotation of 335°–180° with a gantry speed of 360° per minute. The correction reference point was set to the planning target volume (PTV). Goals for PTV doses are guided by recommendations contained in ICRU50/62/83 [21–23], with near minimum (V99%) dose not <95% of the prescription dose and a near maximum dose (V2%) not >107% of the prescription dose. Gross tumour volume outlined includes primary tumour (or resection site/tumour bed, if postoperative) and involved lymph nodes. Clinical target volume (CTV) will usually be taken as gross tumour volume with a margin of 5–10 mm, taking account of normal tissue boundaries and barriers to spread (eg, vertebral