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Technical note

Multi-centre experience of implementing image-guided intensity-modulated radiotherapy using the TomoTherapy platform

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ABSTRACT

Use of image guided (IG) intensity modulated radiotherapy (IMRT) is increasing, and helical tomotherapy provides an effective, integrated solution. Practical experience of implementation, shared at a recent UK TomoTherapy Users' meeting, may help centres introducing these techniques using TomoTherapy or other platforms.

Seven centres participated, with data shared from 6, varying from 2500 - 4800 new patients per year. Case selection of patients "most likely" to benefit from IG-IMRT was managed in all centres by multi-professional groups comprising clinical oncologists, physicists, treatment planners and radiographers. Radical treatments ranged from 94% to 100%. The proportions of tumour types varied substantially: head and neck: range 0%–100% (mean of centres 50%), prostate: 3%–96% (mean of centres 28%). Head and neck cases were considered most likely to benefit from IMRT, prostate cases from IGRT, or IG-IMRT if pelvic nodes were being treated. IMRT was also selected for complex target volumes, to avoid field junctions, for technical treatment difficulties, and retreatments. Across the centres, every patient was imaged every day, with positional correction before treatment. In one centre, for prostate patients including pelvic treatment, the pelvis was also imaged weekly. All centres had designed a 'ramp up' of patient numbers, which was similar in 5. One centre, treating 96% prostate patients, started with 3 and increased to 36 patients per day within 3 months.

The variation in case mix implies wide applicability of IG-IMRT. Daily on-line IGRT with IMRT can be routinely implemented into busy departments.

Introduction

Much has been done in the UK recently to advance the availability of intensity-modulated radiotherapy (IMRT).[1] Existing evidence for the clinical value of IMRT is compelling, and the recent publication of the results from the PARSPORT trial showing reduction in toxicity using IMRT in patients with head and neck cancer[2] increases this evidence,[3,4] as well as adding to the proof-of-principle that better dosimetry achieves a better outcome. IMRT also provides effective treatment solutions for less common, dosimetrically-challenging tumour types.[5–10] Although the trial evidence for image guided radiotherapy (IGRT) is less strong, it is nevertheless a technique which appears likely to deliver improved outcomes,[11,12] by contributing to the precision of treatment delivery.[13,14]

Helical tomotherapy provides an elegant integrated solution for the combination of IGRT and IMRT, and provides a straightforward solution for centres keen to implement these technologies.[5–7,15] Access to volumetric image guidance capability raises a question of how frequently imaging should be performed.[16,17] For a centre starting image-guided IMRT, some degree of 'ramp up' or monthly increase of case numbers is needed in order to become familiar

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with the practical implementation of the system. For most centres, introduction of IG-IMRT imposes a need for case selection, to choose patients most likely to benefit from one or the other or both techniques, presenting an important administrative challenge.

A meeting of UK TomoTherapy users was held in Cambridge in September 2011, and this provided an opportunity to share practical experience of implementing IG-IMRT using the TomoTherapy platform. Although some aspects of this work have been presented previously,[5,15] the experience of this group might be helpful to other centres considering starting an IG-IMRT programme, either with TomoTherapy or alternative platforms.

TomoTherapy user base

There are currently seven TomoTherapy centres in the UK (Table 1), including Birmingham, which was installing two TomoTherapy HD machines at the time of the meeting, and has now started clinical treatment; six centres contributed to the data reviewed here. Representatives from the BUPA Cromwell Hospital took part in the meeting but felt that their experience was not representative of NHS practice.

The centres vary in size from about 2500 new patients per year up to 4800 (Table 1). The size of the centre determines the absolute numbers of patients with different tumour types but in addition there may be regional variations in cancer incidence. Consequently, a medium sized centre such as Cambridge might be able to treat all head and neck cancer patients (excluding early larynx cancer) using a single TomoTherapy unit, but a very large centre, possibly with a higher local incidence of head and neck cancer, may not. This may lead to differences in case mix.

All the centres reported a clear focus on selecting patients requiring radical treatment, although in most a few palliative cases considered likely to benefit were also treated (Table 1). Interestingly, of the first 150 patients treated in Heidelberg, only 76% were treated with radical intent.[6]

Case selection

Centres were asked to describe the main principles for case selection. The over-arching principle of the case selection was to choose patients considered "most likely" to benefit from IG-IMRT. Most centres were choosing head and neck cases, as well as patients with complex target shapes resulting from a variety of conditions. However, in all centres, it was acknowledged that more patients could be identified as "likely to benefit" than there was available capacity. Considering this problem in more detail, patients were typically chosen if they were likely to benefit from IGRT, or IMRT, or both. For IGRT, the feeling was that these were predominantly prostate patients. For IMRT these were predominantly patients with head and neck cancer, complex target volume shapes where field junctions would be best avoided (such as head and neck or craniospinal axis patients), patients with technical treatment difficulties (e.g. bilateral hip replacement, sarcomas with very long fields, pectus excavatum), and those requiring retreatment.

The case mix is shown graphically in Fig. 1. Some specific examples were given by different centres including a focus on head and neck cancer, anal cancer requiring pelvic and inguinal node treatment, thoracic tumours where conventional planning was failing to provide adequate target volume coverage or adequate sparing of lung or spinal cord, and patients with prostate cancer, particularly where the seminal vesicles or pelvic nodes were considered to require treatment. In some centres, it was agreed that different platforms should be used to treat prostate patients, though in one centre the predominant workload was prostate cancer. In this latter case, there were too many prostate referrals to the department for all to be treated on TomoTherapy, so only those requiring treatment to the prostate with seminal vesicles or pelvic nodes were considered suitable.

It was acknowledged that there was an element of clinician interest which determined referrals for TomoTherapy. In all centres, there had to be an IMRT protocol and the relevant referring clinician needed to have been trained in IMRT.

The number of patients that can be treated each day depends on case mix, because both scanning and treatment time depend on the length of the target volume. Simple prostate patients can be treated very fast whilst craniospinal radiotherapy takes substantially longer. In-room time (from entry of maze to exit) depends on a number of factors, including experience, and has fallen with the implementation of software developments.[5] For prostate cancer, current in-room is approximately 12.4 ± 2.01 min (mean ± standard deviation), with mean beam-on time of 3.3 ± 1.03 min, for 123 consecutive patients, receiving radiotherapy to the prostate plus seminal vesicles [Cambridge, unpublished data]. By comparison, 3 consecutive craniospinal axis radiotherapy cases had a mean in-room time of 25.1 ± 4.90 min, with mean beam-on time of 8.9 ± 0.49 min [Cambridge, unpublished data].

Frequency of imaging

In four of the five centres already treating, every patient was imaged every day, with positional correction applied before treatment delivery. In Birmingham, the stated intention was also to use this approach. At Guys and St Thomas' Trust (GSTT) patients being treated for prostate cancer were imaged daily, with weekly whole pelvis imaging in patients receiving radiotherapy to the pelvic lymph nodes.

Table 1
Centres contributing to the analysis, in order of starting clinical treatments, number of units, new patient numbers per centre, and percentage of radical cases treated on TomoTherapy.

Centre	Date of starting TomoTherapy	Number of units	Approximate size of centre (new RT cases per year)	Percentage of radical cases
Cambridge	2007 October	1 from 2007 2 from 2010	4000	96%[c]
Newcastle	2009 March	1	4800	94%
Middlesbrough	2010 June	1	2700[b]	100%
GSTT	2010 November	1	4100	97%
Nottingham	2011 June	1	2500	100%
Birmingham[a]	(2011 November)	2	4000	~100% expected

GSTT = Guy's and St Thomas' Trust.

[a] Birmingham had commenced installation but not clinical treatments at the time of the meeting, although their first unit started clinical treatments in November 2011. However, they had developed implementation strategies which were relevant to the discussions.

[b] Approximation, based on 1590 new patients receiving radical RT, and an assumed Radical: Palliative ratio of 60:40.

[c] The same percentage was noted for the first 100 cases and the first 1000.