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FULL PAPER

A prospective study comparing radiographer- and clinician-based localization for patients with metastatic spinal cord compression (MSCC) to assess the feasibility of a radiographer-led service

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Objective: To investigate whether there was parity between treatment fields localized by radiographers and clinicians, by comparing geographical variations and hence determining the feasibility of a radiographer-led service.
Methods: 23 patients with metastatic spinal cord compression (MSCC) were prospectively sampled. Four radiographers not involved in the original planning performed localization on each patient. The 92 localizations that they determined were compared with the clinician-approved fields. Agreement was defined as ≤0.5 cm between field length, width and three isocentre co-ordinates. To be feasible, agreement was required in a minimum of 97% of the cases. The potential time saved with a radiographer-led approach was also recorded.
Results: Agreement between clinicians and radiographers was 97.8%. For all field parameters, the average differences were <0.3 cm and were significantly different from the 0.5-cm median ($p < 0.0001$) that would establish no agreement using Wilcoxon signed-rank test. The average (range) delay awaiting clinician approval was 54 min (4–141 min).
Conclusion: Strong agreement between radiographer and clinician localizations was established. It was also highlighted that time could be saved in the patient's pathway by removing the need to wait for clinician approval. We believe this supports a radiographer-led service.
Advances in knowledge: This article is novel, as it is the first known comparison between clinicians and radiographers in the localization of MSCC radiotherapy. These data show the feasibility of introducing radiographer-led practice and a methodology that could be potentially transferred to investigate the localization parity for other treatment sites.

INTRODUCTION

Metastatic spinal cord compression (MSCC) is a neurological complication of advanced malignancy[1] second only to brain metastasis in frequency. It is spinal cord and/or cauda equina compression of the thecal sac by direct pressure, instability by metastatic spread, induction of vertebral collapse or direct extension of malignancy into the epidural space.[2] Once a diagnosis of MSCC has been established, it is an emergency within oncology that necessitates rapid onset of treatment within 24 h.[2]

Incidence

Not all malignancies have the same pre-disposition to cause MSCC. Of the patients who experience MSCC, 15–20% of MSCC is caused by lung, breast and prostate cancer;[3] up to 5–10% from renal cell carcinoma, multiple myeloma and non-Hodgkin's lymphoma; and the remainder attributed to sarcoma, colorectal cancer and tumours of an unknown primary.[4]

Therefore, the frequency of MSCC will depend on the population of patients and their relative tumour histology. Such that, the number of cord compressions seen is a function of the number of patients with a tumour type and the tendency of that tumour type to metastasize to the spine.

The lack of a coding system prevents any accurate determination of true spinal cord compression incidence within the UK.[2] However, with tumours most likely to cause MSCC (prostate, breast and lung) accounting collectively for 41% of all cancer cases,[5] it is apparent that MSCC affects a relatively

large number of patients each year. Intelligent estimates put the incidence at 4000 cases in England and Wales each year.[6]

Management

The management of MSCC is multimodal with steroids, surgery and radiotherapy being utilized.[7] It is often the case that one single treatment is not used and the treatment options are adjuvant, with radiotherapy playing a vital role.[3]

Despite superiority in effectiveness of using surgery, not all patients with MSCC are medically suitable for surgery, and radiotherapy remains the primary treatment for this patient group.[8] The benefits of radiotherapy for MSCC have been demonstrated when 71% of patients investigated who received radiotherapy for MSCC experienced pain relief, with 81% of patients maintaining ambulatory status.[9] Similarly, all patients, who were ambulatory prior to radiotherapy ($n = 93$), maintained this status up to 20 months post treatment.[3] The general consensus is that radiotherapy is a vital and widely utilized treatment modality for patients with established MSCC.[10]

The conventional technique used to treat MSCC is very similar across Europe.[11] A single posterior beam centred at the level of compression, at depth to the anterior spinal cord is used. The field width is typically 8–10 cm to the distal aspect of the transverse processes.[7,12] It is also well established that one uninvolved vertebrae above and below the level of compression should be irradiated owing to a high rate of recurrence in these vertebrae,[13] with the superior and inferior borders placed at the intervertebral spaces.

Advances in radiotherapy have led to a number of novel treatment modalities being observed such as intensity-modulated radiotherapy and stereotactic radiosurgery;[14–16] however, specific work[2] relating to the radiotherapy process, improving the efficiency of conventional practice and the patient pathway has not been found, although it has been recommended.

Radiotherapy pathway

Any delay in the pathway can have a significant impact on the timing of treatment and thus a detrimental effect on patient experience.[17] One way to improve MSCC radiotherapy would be to optimize the associated pathway, to maximize efficiency to meet the demands set by National Institute for Health and Care Excellence (NICE)[2] and to ensure that treatment delivery is on the same day as the planning scan. In addition, patients with MSCC can often be in pain and discomfort,[18] and waiting for prolonged periods may make the patient more uncomfortable.

Current practice in our radiotherapy department demonstrates that, once the patient is referred, every stage in the pathway is radiographer led, other than the approval of the treatment field (Figure 1), and this stage is where the most significant and regular delays occur.

There are a number of potential justifications for this delay. Firstly, there is often a conflict in demand for clinician time, for example, attending clinics, ward rounds, Multidisciplinary Team (MDT) meetings and organ contouring, that they are not available to attend localization. In addition, the emergency *ad hoc* nature of patients with MSCC means that they are not always booked in line with that particular clinical team's availability.

With a standardized technique and protocols to follow, there is little subjectivity attributed to localizing MSCC. For the majority of localizations, it is the researcher's experience that the initial field localized by a radiographer is not changed by a clinician; hence, the delay caused by waiting for approval may be unnecessary.

The large workload of clinical oncologists has been acknowledged in the National Radiotherapy Advisory Group report[19] which drew attention to their expanding patient base and the fact that many clinical oncologists are "hard pressed". Renegotiating roles within radiotherapy and transferring some of their tasks to radiographers, namely localizing MSCC radiotherapy would help to reduce this workload.

If the need for clinician approval is removed and radiographers are given authorization to approve these treatments, the delays that can occur could be eliminated. This would improve the service through streamlining the pathway and enhance patient experience owing to a reduction in waiting time from planning to treatment.[20]

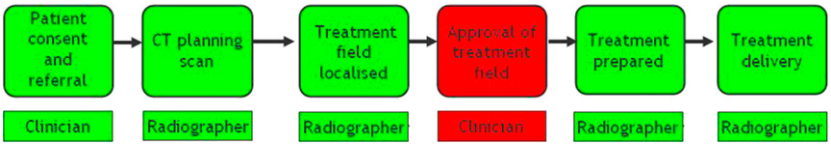
Although there are no published studies comparing clinician and radiographer localization for MSCC radiotherapy, there is evidence to show a considerable degree of parity in treatment verification[21] and breast simulation[22] (97% and 97.3%, respectively). We have therefore investigated whether there is parity between clinicians and radiographers in the localization of MSCC.

Professional development

The renegotiation of National Health Service (NHS) roles is not a novel concept,[23] with changes in workforce configuration and skill mix being a growing trend for a number of years.[24] Reasons are being attributed to the need to improve organizational effectiveness and pressures for better management of labour costs.[25]

Within radiography, the four-tier service model was introduced by the Society and College of Radiographers (London, UK)[26] with the aim of establishing consultant and advanced practice roles. The target of this model is to make more effective use of clinical oncologists' time by delegating certain roles to radiographers[19] in view of the expanding workload.

Figure 1. The local metastatic spinal cord compression pathway.



The introduction of radiographer-led localization for MSCC could help to establish progression into these advanced roles. This is because it would achieve the characteristics required at this level of expert clinical practice, service development and consultancy.[22] Where these roles have been introduced, they have demonstrated the potential to make more efficacious use of clinical oncologists' time as well as drive patient pathway efficiency, reduce waiting times and offer a more patient-led service.[19]

METHODS AND MATERIALS

From April 2014, every consecutive patient with MSCC requiring treatment on the same day as planning CT was selected. Patients also must have had MRI confirmation of MSCC and a completed radiotherapy referral stating the specific vertebral levels to be treated.

Radiographers who had been trained in virtual simulation as part of the radiotherapy department's clinical competency framework were included in the study. This required prior training in localizing palliative radiotherapy fields and completion of an associated competency workbook. This involved recording a log of experiences complemented by reflective practice. Therefore, radiographer grade was not discriminated against, providing the radiographer was trained and completed the workbook, they were included.

In addition, the radiographers who took part in the original localization and checking of the field with the clinician were excluded for that particular data set. This was to remove recall bias and the associated threat to data reliability this yields.[27]

Data collection

Once referred for treatment and consented, the patient had planning CT as per normal clinical procedure, that is, positioned supine, arms by their sides with a knee pad. Once completed, the CT data set was sent to the treatment planning system. An initial field to treat compression was localized by a radiographer under normal departmental procedure. After initial localization, a clinician was called to review the field, to make any requisite changes and to approve the treatment.

The time taken for a clinician to attend, from the moment they were contacted to the time when the treatment was approved, was recorded.

Once completed, the field size was recorded by the researcher to determine the differences in irradiated volume, and the isocentre co-ordinates were recorded to provide geographical differences including the treatment depth chosen.

The planning referral and CT scan were then anonymized, and four radiographers not involved in the original localization independently localized a treatment field.

Once the four independent localizations had been performed, the radiographer data ($DATA_{rad}$) was compared with the clinician data from the original approved treatment field ($DATA_{clin}$). This was performed by the researcher.

Rate of agreement

Based on previous studies investigating parity,[21,22] the primary end point in this study was 97% agreement between radiographers and clinicians. This rate of agreement would establish parity between them indicating that a radiographer-led service is feasible.

To reinforce the need for 97% agreement, it has also been suggested that 87.5% agreement between radiographers and clinicians is not sufficiently high to support a radiographer-led system.[28] Therefore, a higher rate of agreement is needed, and thus, 97% could be argued as showing sufficient parity.

Classification of agreement

For the purpose of this study, agreement was classified as $\leq$0.5 cm between field length, width and three isocentre co-ordinates. If any one of the five parameters was greater than this tolerance, the localization was deemed as not in agreement.

The justification for this was 0.5 cm is within the imaging tolerance that MSCC would be treated within the researchers' radiotherapy department. Also, as one uninvolved vertebrae above and below the actual compression is treated (Figure 2a), and the lateral margins are >1 cm (Figure 2b) when the edge of transverse processes are used, a 0.5 cm displacement at localization would not illicit a geographical miss of the compression at treatment delivery.

Sample size

Assuming that the true rate of agreement is 97%, the sample size for this study in order to prove the rate is greater than a minimum of 90% was 92 localizations when a one-sided alpha of 0.05 was used in order to obtain an associated statistical power of 85% which is above the benchmark of 80% power for results to be valid and reliable.[29] This was calculated using SPSS® (IBM Corporation, Armonk, NY; formerly SPSS Inc. Chicago, IL). Therefore, 23 patients would be needed as 4 different radiographers would perform a localization for each patient, to be compared with the clinician-approved field used to treat the compression.

Statistical considerations

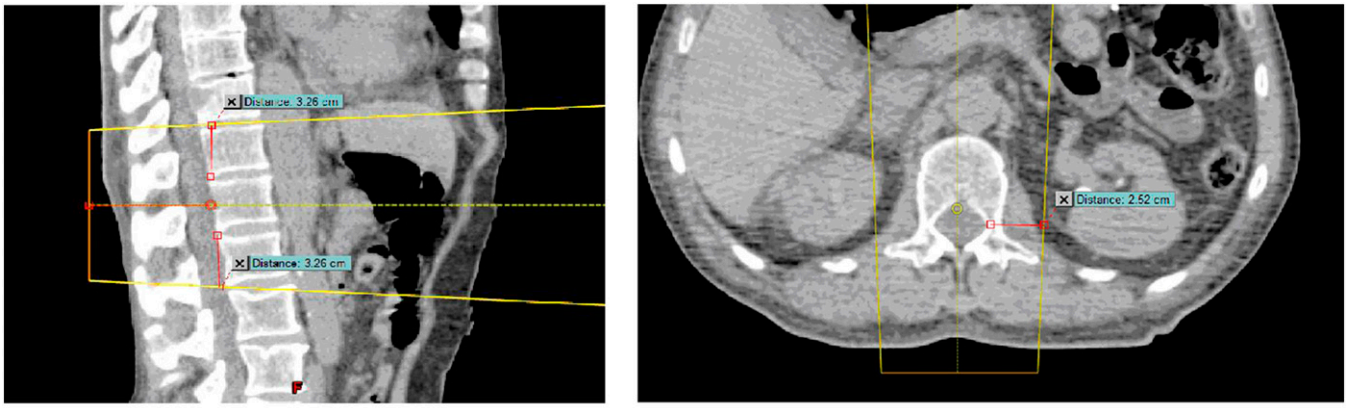
To analyse the data, descriptive statistics was used to quantify and illustrate the differences in field parameters between radiographers and clinicians. In addition to highlighting the level of parity between the two professional groups, this also enabled evaluation of interradiographer variability.

Once the data had been collected, it was evident that the conditions of normality were not met. The non-parametric data were therefore tested using Wilcoxon signed-rank test in order to obtain the respective *p*-values for each of the five field parameters.

Ethical approval

This study did not involve any change to clinical care of the patient or any identifiable patient data. It therefore did not require ethical review by a NHS or social care research ethics committee, or management permission through the NHS research and development office. Ethical approval was sought through the trusts' clinical audit committee to ensure compliance with the trusts' ethical policy.

Figure 2. (a) Sagittal view of field placement. (b) Axial view of field placement.



(a) (b)

RESULTS

In 90 of the 92 localizations, parity with the clinicians was established in all of the five parameters measured resulting in an overall rate of agreement of 97.8%. The average differences were <3 mm in all parameters and significantly different from 0.5 cm (Wilcoxon signed-rank test) (Table 1).

The results also showed a trend of the radiographers to localize a smaller field width (49% smaller, 34% larger and 17% no change) which can be observed in Figure 3 and a smaller field length (48% smaller, 33% larger and 19% no change) compared with the approved clinician field (Figure 4).

The average delay in waiting for a clinician to approve the original field was 54 min (standard error = 0.61), and the range of time delay was 4–145 min (Figure 5).

DISCUSSION

Rate of agreement

We have demonstrated that radiographer localization of MSCC agreed with clinicians 97.8% of the time, hence rendering the average delay of nearly an hour unnecessary.

The results here are comparable with those previous similar studies[21,22] where parity was found. In both cases, clinical implementation of the radiographer-led service took place with satisfaction that practice was safe and of no detriment to patients.

Furthermore, the rate of agreement of the results in this study is greater than the recommended threshold of 87.5%[28] to implement a radiographer-led service. Moreover, this study has shown that in relation to localizing the treatment fields for MSCC, a radiographer-led service is a safe and feasible option.

Geographical variations

Firstly, the very high rate of agreement illustrates the small geographic variation in the field produced by the two groups. This is further reinforced by the fact that in 100% of the localizations, the isocentre co-ordinates agreed with those of the clinician.

This underpins the very robust nature of the treatment protocol used to treat MSCC and the lack of subjectivity involved. The treatment fields are localized based on anatomical landmarks, with little justification to deviate from these. Therefore, radiographers localize extremely similar fields as a clinician in order to treat the same MSCC.

In the case of this study, the radiographers were given an identical albeit anonymized copy of the original treatment referral describing the vertebral levels to be irradiated. However, this meant that all clinical information on the electronic patient record system along with associated diagnostic imaging, notably MRI which was available to the clinician when approving the localization and was not accessible to the radiographers. In light of this limitation and the fact that they still achieved 97.8% agreement again highlights the minimal difference between the two groups.

In the two cases whereby radiographer localization did not agree with clinician localization, both were due to the field width exceeding the 0.5-cm tolerance. Although this was only by 0.1 and 0.5 cm, it is still important to explore possible causes. In both of these cases, the patient had a soft-tissue deposit. This has shown that the radiographers have placed a margin on this disease albeit slightly larger than that by the clinician.

In view of the fact that MRI was not available, it could be argued that this may be a case of being cautious to ensure that the disease would be adequately treated. The superior image quality of MRI that would have been available to the clinician meant that they could have made a more accurate assessment as to the requisite field width needed to treat the compression. However, in these two cases, the disease had a greater margin on it; therefore, the inference can be made that without similar imaging, the radiographer-ensured disease was adequately covered to minimize the risk of geographical miss.

Finally, when discussing the geometric and geographic results of this study, a pattern emerged that illustrated a tendency of the radiographers to localize slightly smaller fields than the clinician. Reasons for this could be that, again, radiographers as professionals are process and protocol driven, with a tendency not to deviate from protocol or work outside of their delegated role. Therefore, they could be less likely than clinicians to increase field sizes beyond the anatomical landmarks required.

Table 1. Average differences between radiographers and clinicians

Field parameter	Average difference (standard error) (cm)	Difference from 0.5 cm, *p*-value
x co-ordinate	0.17 (0.01)	<0.0001
y co-ordinate	0.16 (0.02)	<0.0001
z co-ordinate	0.09 (0.01)	<0.0001
Field length	0.22 (0.03)	<0.0001
Field width	0.27 (0.03)	<0.0001

Radiographers also have a greater knowledge and awareness of image verification performed at treatment, its efficacy and the implications this has on improved treatment accuracy. Moreover, this could lead to radiographers having greater confidence on standard margins used to treat MSCC compared with clinicians and therefore tend not to increase the field borders beyond this standard.

Time delay

An average delay of 54-min waiting has highlighted that clinical oncologists are not always readily available to attend straight away. These data have not been recorded to expose non-punctilious behaviour of the clinicians involved but to show that attending virtual simulation at any time is not conducive in line with their expanding workload and clinical commitment. As a result of this, there is an associated delay awaiting this 24-hour radiotherapy pathway that has the potential to be removed.

Service improvement

The outcomes of this study have shown an optimal area, whereby the clinician's workload could be alleviated whilst improving patient service. The role of localizing treatment of MSCC could be delegated to radiographers, given the very strong level of agreement established here.

A radiographer-led service for patients with MSCC would yield a more efficient and streamlined pathway through the removal of this delay. This is in line with high standards of patient care owing to the fact that there is significant agreement between clinicians and radiographers in the execution of treatment localization. Reducing waiting times would also have a positive impact on patients.[20]

It is important to also highlight that the delay caused at virtual simulation is not the true reflection of the actual delay experienced. This delay has an accumulative effect, and there is the potential for the delay to be more significant in latter stages of the patient pathway.

Cost saving

From an operational perspective, the elimination of delay associated with the clinician-led service would also reduce the potential of requiring radiographers to work out of hours. If the localization is not performed in a timely manner, the delivery of treatment may be out of hours. This will clearly have implications to the cost of the service as overtime caused by radiographers working late would be reduced.

There are potential further cost-saving benefits to a radiographer-led service in view of concepts such as activity-based costing. Systems such as these may show that in fact it is cost beneficial to have radiographers perform a task previously performed by clinicians. Therefore, a radiographer-led service would show better management of labour costs and organizational effectiveness.[25] Again, the potential benefits based on this

Figure 3. Difference in field width between clinician and radiographer.

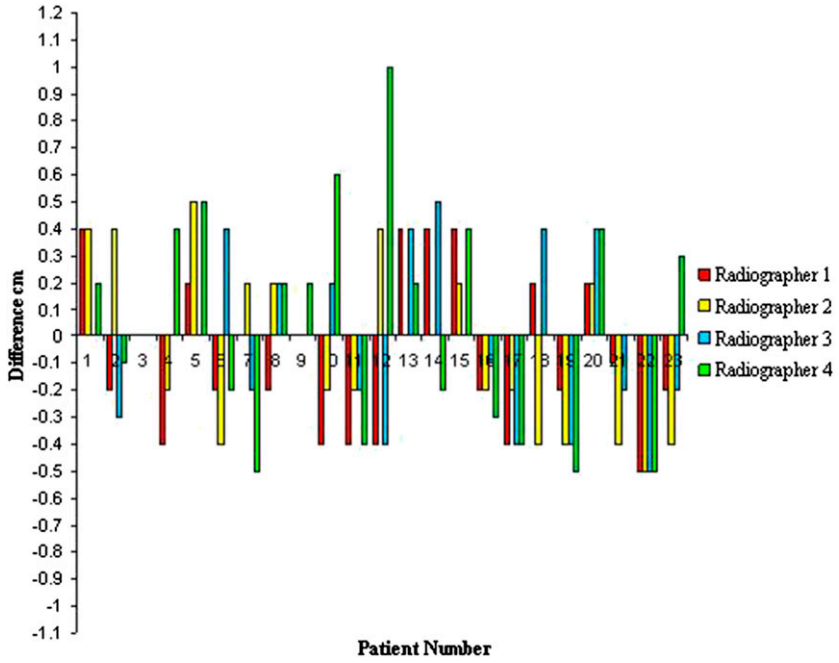
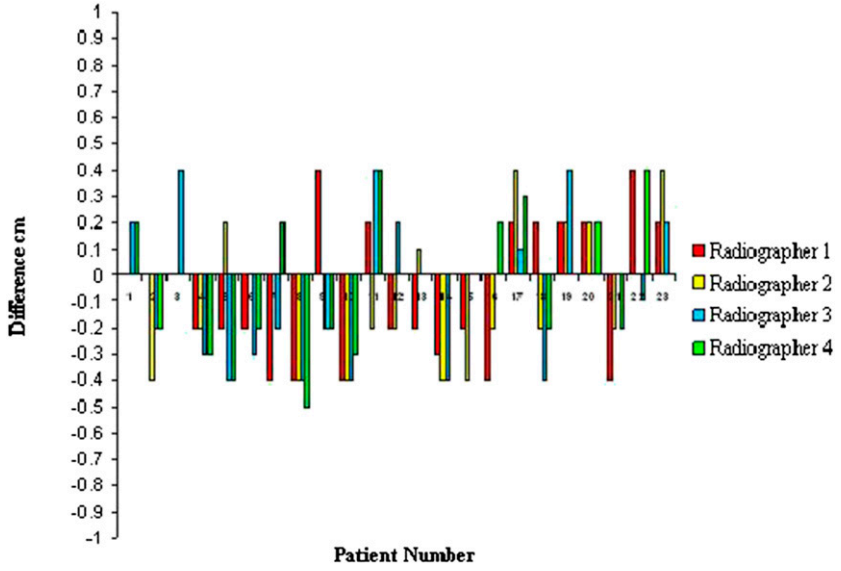


Figure 4. Difference in field length between clinician and radiographer.



study are shown, suggesting that a radiographer-led service is a viable option to improve the service, and although it would need support from a strategic level in order for it to be implemented effectively, it would have the potential to improve the pathway for patients with MSCC considerably.

Professional development

The results of the study have clearly shown that radiographers are capable of localizing MSCC radiotherapy accurately and safely without the need of clinician approval. The outcome of 97.8% agreement supports the notion that this role could be delegated to radiographers; in turn improving the profile of the profession with the introduction of advanced practice roles, given the associated characteristics, expert clinical practice, service development and consultancy.[22]

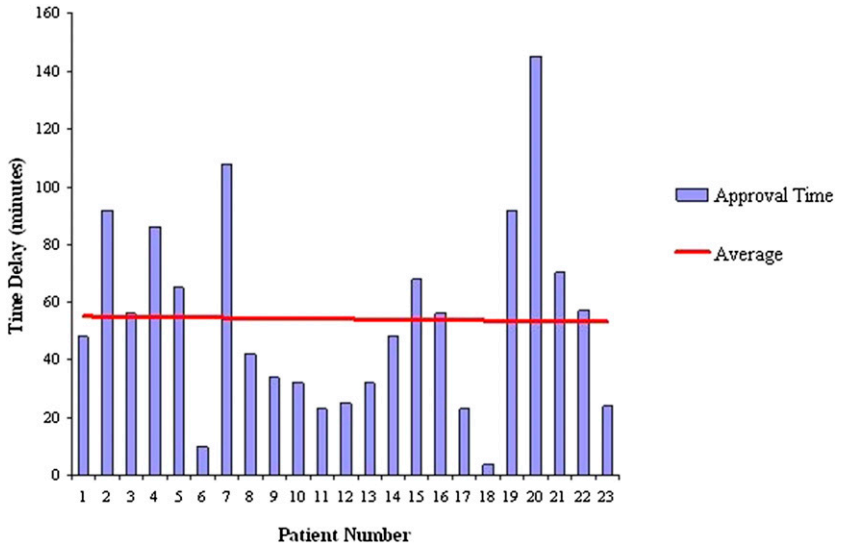
Moreover, it has been shown that a radiographer-led service could be implemented that would ultimately make this cancer service more responsive to the needs of the patient, in line with historic government targets that staff need to renegotiate their roles.[23]

Strengths and limitations of the study

As previously highlighted, there was assumed independence between the four radiographers involved in the localization of a patient. Ideally, 92 patients would have been recruited to meet the sample of 92 localizations; however, it was not possible owing to the time limits set and presented an obvious limitation to the study.

In addition, the time delay itself had been obtained but the reason for the delay was not. In retrospect, it may have been

Figure 5. Approval time delay.



beneficial to the study to have ascertained a reason for the delay. This would have aided the discussions of the results and enabled some inferences to be drawn as to the source of the delay from a clinician's perspective. This poses a potential for further study.

CONCLUSION AND RECOMMENDATIONS

Within the 0.5-cm tolerance set within this study, there is a robust agreement between clinicians and radiographers in localizations of MSCC radiotherapy. As a result, evidence is presented that supports the implementation of a radiographer-led service for this patient group in order to streamline the patient pathway and make the service more efficient in line with high standards of patient care.

It is recommended that the radiographer-led service be clinically implemented in the first instance as a trial basis. A sample of the first patients could then be retrospectively evaluated to see whether they were changed at audit after localization had been approved by trained radiographers. Assessment of the frequency that they are changed and the associated magnitude of any changes made should be performed in order to evaluate the accuracy and safety of this service. The time saved could also be evaluated in order to assess whether or not the pathway has in fact been streamlined.

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REFERENCES

1. Hoskin P, Grover A, Bhana R. Metastatic spinal cord compression: radiotherapy outcome and dose fractionation. *Radiother Oncol* 2003; **68**: 175–80.
2. Guideline NICE. *Metastatic spinal cord compression: diagnosis and management of patients at risk of or with metastatic spinal cord compression*. London, UK: National Institute for Health and Clinical Excellence National Collaborating Centre Cancer; 2008.
3. Halweg-Larsen S, Sørensen PS, Kreiner S. Prognostic factors in metastatic spinal cord compression: a prospective study using multivariate analysis of variables influencing survival and gait function in 153 patients. *Int J Radiat Oncol Biol Phys* 2000; **46**: 1163–9.
4. Schiff D. Spinal cord compression. *Neurol Clin* 2003; **21**: 67–86. doi: 10.1016/S0733-8619(02)00033-6
5. Cancer Research UK. *UK cancer incidence statistics*. London, UK: Cancer Research UK; 2010.
6. Nair C, Panikkar S, Ray A. How not to miss metastatic spinal cord compression. *Br J Gen Pract* 2014; **64**: e596–8. doi: 10.3399/bjgp14X681589
7. Prasad D, Schiff D. Malignant spinal cord compression. *Lancet Oncol* 2005; **6**: 15–24.
8. Loblaw DA, Laperriere NJ, Mackillop WJ. A population-based study of malignant spinal cord compression in Ontario. *Clin Oncol (R Coll Radiol)* 2003; **15**: 211–17.
9. Turner S, Marosszeky B, Timms I, Boyages J. Malignant spinal cord compression: a prospective evaluation. *Int J Radiat Oncol Biol Phys* 1993; **26**: 141–6.
10. Abrahm JL. Assessment and treatment of patients with malignant spinal cord compression. *J Support Oncol* 2004; **2**: 377–88.
11. Lievens Y, Kesteloot K, Rijnders A, Kutcher G, Van den Bogaert W. Differences in palliative radiotherapy for bone metastases within western European countries. *Radiother Oncol* 2000; **56**: 297–303.
12. Loblaw DA, Laperriere NJ. Emergency treatment of malignant extradural spinal cord compression: an evidence-based guideline. *Clin Oncol* 1998; **16**: 1613–24.
13. Kaminski HJ, Diwan VG, Ruff R. Second occurrence of spinal epidural metastases. *Neurology* 1991; **41**: 744–6.
14. Ryu S, Fang Y, Rock J, Zhu J, Chu A, Kagan E, et al. Image guided and intensity modulated radiosurgery for patients with spinal metastasis. *Cancer* 2003; **97**: 2013–18.
15. Gerszten PC, Ozhasoglu C, Burton SA, Vogel WJ, Atkins BA, Kalnicki S, et al. Cyberknife frameless stereotactic radiosurgery for spinal lesions: clinical experience in 125 cases. *Neurosurgery* 2004; **55**: 89–99.
16. Guckenberger M, Meyer J, Wilbert J, Baier K, Bratengeier K, Vordermark D, et al. Precision required for dose-escalated treatment of spinal metastases and implications for image-guided radiation therapy (IGRT). *Radiother Oncol* 2007; **84**: 56–63.
17. Lee K, Tsou I, Wong S, Yu C, Ming Z, Loh Y, et al. Metastatic spinal cord compression as an oncology emergency: getting our act together. *Int J Qual Health Care* 2007; **19**: 377–81. doi: 10.1093/intqhc/mzm043
18. Tobias J and Hochhauser D. *Cancer and its management*. 6th edn. Oxford, UK: Blackwell Publishing; 2010.
19. NRAG. *Radiotherapy: developing a world class service for England Report to Ministers from National Radiotherapy Advisory Group*. London, UK: Department of Health; 2007.
20. Blyth C, Anderson J, Hughson W and Thomas A. An innovative approach to palliative care within a radiotherapy department. *J Radiother Pract* 2001; **2**: 85–90.
21. Suter B, Shoulders B, Maclean M, Balyckyi J. Machine verification radiographs: an opportunity for role extension. *Radiography* 2001; **6**: 245–51.
22. Welgemoed C. Role development for therapy radiographers in breast planning: a case study and discussion of influencing factors. *J Radiother Pract* 2008; **7**: 47–57.
23. Department of Health. *The NHS cancer plan: a plan for investment: a plan for reform*. London, UK: Department of Health; 2000.
24. Davies C. *The future health workforce*. 1st edn. Basingstoke, UK: Palgrave Macmillan; 2003.
25. Sibbald B, Shen J, McBride A, Zafar R, Grimshaw D. *Changing skill mix in the NHS. Manchester School of Management*. Manchester, UK: UMIST; 2002.
26. Society of Radiographers. *A strategy for the education and professional development of therapeutic radiographers*. London, UK: Society of Radiographers; 2000.
27. Hassan ES. Recall Bias can be a threat to retrospective and prospective research designs. *Int J Epidemiol* 2005; **3**: 4.
28. Renwick I, Butt W, Steele B. How well can radiographers triage X-ray films in accident and emergency? *BMJ* 1991; **302**: 568–69.
29. Crichton N. The importance of statistics in research design, In Lewith GT and Aldridge D, eds *Clinical research methodology for complementary therapies*. London, UK: Hodder and Stoughton; 1993.