

An evaluation of techniques used in superficial radiotherapy for non-melanoma skin cancer to replicate the planned treatment area: A prospective study



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ABSTRACT

Introduction: Accuracy of superficial radiotherapy for non-melanoma skin cancer is dependent on replicating the original clinical mark-up. Responses from 18 UK Radiotherapy centres identified the four most common replication techniques; the accuracy and time-efficiency of each was evaluated, as well as participant preference and confidence.

Methods: A 2.0 cm × 2.5 cm ellipse field was drawn around the nasal ala of a surrogate patient. Templates for each replication method (1–4) were created, and skin marks removed. Twenty-five therapeutic radiographers used each method to replicate the mark-up. Measurements were recorded for lateral and longitudinal displacement, ellipse diameter and time taken. A post-study questionnaire recorded participant preference and perceived confidence.

Results: Comparison of the mean ellipse areas for methods 1–4 identified no statistically significant differences (ANOVA test; $p = 0.579$ to $p = 0.999$). Lateral and longitudinal displacements for method 1–4 showed a statistically significant difference between method 3 and each of methods 1, 2, 4 for lateral and longitudinal respectively (ANOVA; lateral: $p = 0.008$, $p = 0.002$, $p = 0.05$; longitudinal: $p = 0.036$, $p = 0.000$, and $p = 0.000$). Mean time taken was longest for method 3, and was compared using a Friedman test ($p = 0.000$) identifying a statistically significant difference. Twenty-two participants completed the questionnaire. 48% favoured method 2, 41% method 4. Method 3 was least favourite. A Likert scale (1–10) measured confidence. Participants had most confidence in methods 2 and 4.

Conclusion: In this study, method 3 was least accurate, most time consuming, and was least favoured by users. The clinical significance of these results will depend on the margins used in local practise.

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Introduction

Non-melanoma skin cancers (NMSC) are the most common type of cancer in the UK, and have been described as a global epidemic.¹ The most recent statistics report an incidence of 131,772 cases registered in 2014 in the UK,² although the actual incidence is understood to be significantly higher, and it is estimated that 30–50% of NMSC are not reported.¹ Over 80% of these present on the head and neck,³ characteristically on sun-exposed areas of the face, particularly on the nose, nasal ala, nasolabial fold, auricular helix, and the inner canthus of the eye.⁴ These sites present their

own difficulties in treatment, due to their small target areas and inherent contours, which can make both radiotherapy set-up and surgery particularly awkward.

The objective of NMSC treatment is to eradicate the cancer, whilst achieving the best possible cosmetic outcome is of particular concern where the cancer is located on a patient's face.⁴ The resulting appearance can have a significant impact on quality of life⁵ as poor cosmesis can damage self-esteem and social relationships.⁶

In the UK, an estimated 6000 patients are treated with kilovoltage radiotherapy annually.⁷ Successful radiotherapy is dependent on the inclusion of the entire clinical target volume (CTV) within the treatment field for every fraction. In superficial radiotherapy for well-defined basal cell carcinomas (BCC), a standard gross tumour volume (GTV) - CTV margin of 0.5 cm is accepted, and for poorly defined BCC and for squamous cell carcinomas (SCC), a 1 cm margin is required.⁴

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A recent study used a modified version of Mohs micrographic surgery to compare these recommended CTV margins with the actual margins of microscopic tumour identified.⁸ From the 159 lesions studied, depending on the size of the tumour and its histological type, margins in the range of 1.0 cm–1.3 cm were recommended for BCC, and 1.1 cm–1.4 cm for SCC.⁸ Although there were limitations to this study, for example the depth of infiltration was not considered, the results do raise a question as to whether the standardised CTV margins currently used are sufficient. Within literature for superficial radiotherapy, the CTV is referred to as the planning target volume (PTV), without clarification of additional margins added to account for other variables, such as random errors in the patient's set-up at each fraction.⁹ The impact of random errors is exacerbated if the treatment plan has not accounted for these in the margin calculations.¹⁰

In superficial radiotherapy, applicators are used to collimate the radiation beam, attenuate scattered radiation, and define a precise field size.¹¹ In order to minimise geometric errors, there must be robust techniques to ensure the original treatment field delineated by the clinician is accurately replicated on the patient's skin for every fraction. If the treatment field is incorrectly replicated, part of the CTV may be missed for one or more fractions, which could decrease the probability of tumour control and raise the risk of future recurrence⁸; in addition, more healthy tissue will be inside the treatment field and receive an unnecessary radiation dose, raising the risk of morbidity and worsening cosmetic outcome.⁸

If, as some studies have reported, the GTV to CTV margin is inadequate,⁸ this compounds the risk that any small errors in treatment field replication will lead to incomplete coverage of the microscopic disease.

There is currently no consensus or published evidence-based practise on the optimal replication technique for superficial radiotherapy. A scoping search of the literature returned no comparisons or guidance on replication techniques. A scoping survey asked members of the UK Society of Radiographer's superficial radiotherapy Special Interest Group for the technique used in their individual radiotherapy centres. Eighteen responses, representing approximately a third of centres in the UK that have a superficial radiotherapy unit, identified seven different replication techniques (Table 1). Some centres used more than one approach, depending on the individual patient's needs and the location of the tumour.

Time constraints and suitability for use on a surrogate patient limited the number of techniques that could be evaluated. The aim of this study therefore was to critically evaluate four commonly used techniques for replicating superficial treatment marks.

Method

Ethical approval was awarded by the University of Liverpool's Health and Life Sciences Committee on Research Ethics (Human participants, tissues and databases).

Table 1

A summary of the replication techniques used in 18 UK radiotherapy centres.

Replication Technique	Number of Centres
Acetate/plastic sheet template plus photograph	14
Photograph with measurements from anatomical landmarks	6
Outline marks kept on patient throughout treatment	5
Partial thermoplastic masks	4
Custom lead masks	2
Ultraviolet tattoo	1
Acetate/plastic sheet template with tracing holes along outline	1

A single patient surrogate was identified and written informed consent obtained to define treatment fields via marker pen on their face and use photographs.

A treatment field outline was drawn on the left lateral nasal wall of the patient. A 2 cm by 2.5 cm ellipse was chosen from a selection of standard superficial cut-outs, as this was the best fit for the location and individual. The nose was chosen as it is a common treatment site for NMSC. A challenging area of anatomy was selected as it poses more difficulties for replication and set-up than a smooth, flat surface.

Templates, measurements and photographs for all replication methods were then created. Each replication technique was allocated a method number (Table 2).

Method 1

An acetate sheet was placed over the treatment field outline and the participant's facial features. The outline was traced through the sheet with permanent pen, and facial structures were drawn on, including their left ala, the nose, the left inner canthus and outline of the left closed eyelid and eyebrow. These features were then labelled on the acetate template (Fig. 1). The department's medical illustrator took close up photographs of the treatment area and outline for reference.

Method 2

An identical acetate sheet template was created, and 2 mm holes made at intervals along the treatment field outline with a specialised single hole-punch (Fig. 2). The department's medical illustrator took close up photographs of the treatment area and outline for reference.

Table 2

Replication technique method numbers.

Replication Technique	Method Number
Acetate sheet template plus photograph	1
Acetate sheet template with tracing holes along outline	2
Photograph with measurements from anatomical landmarks	3
Partial thermoplastic mask	4

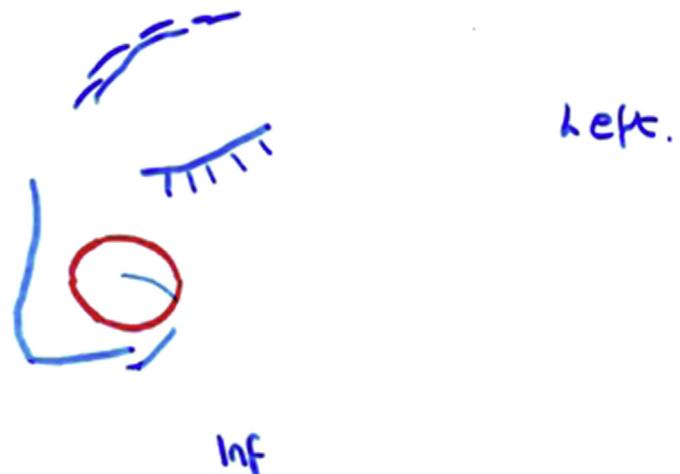


Figure 1. Method 1 acetate sheet template.

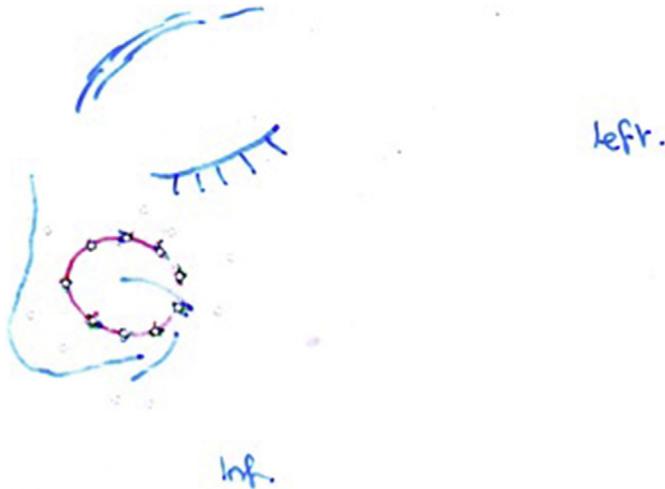


Figure 2. Method 2 acetate sheet template plus tracing holes.

Method 3

Measurements from the anatomical landmarks were drawn on to the photograph taken by the medical illustrator (Fig. 3).

Method 4

A pre-prepared partial thermoplastic mask was placed on the participant's face and the outline of the treatment field traced through it. The outlined area was precisely cut out to create a stencil of the treatment field (Fig. 4).

A pre-prepared clear plastic mask of the patient's head was used to record the gold standard position of the original planned treatment marks as this a well-established technique for isocentric replication in head and neck radiotherapy (Fig. 5). The gold standard mask was used to measure radiographer replicated outlines, and the differences in size and position. The mask was replaced several times to ensure that the marks continued to reflect the position of the marks on the skin without distortion. The mask refitting was undertaken by the individual involved in measuring displacements throughout the process to ensure consistency.

A total of twenty-five radiographers were recruited as participants in the project. All participants were registered therapeutic radiographers working at a single radiotherapy centre. All grades currently in clinical roles were eligible to participate except for those specialising in superficial radiotherapy. These were excluded as they may introduce a positive bias towards that centre's replication method due to their high level of experience with this technique. A participant information sheet was emailed to participants one week prior to the study. Written informed consent was given by each participant before the start of the study. A code was allocated to each participant in order to anonymise all data collected on the practical study in order to triangulate with individuals' questionnaire responses.

Data collection

Data collection sheets were created with each method listed in a randomised order for each coded participant. Randomisation avoided bias due to familiarity with the field outline as they progressed through the study. To minimise any set-up variables that could influence the results, the same lighting, treatment couch and pillow were used throughout the study. Each participant used the same marker pen provided by the study team to remove any variability in area caused by differences in line thickness due to variations in marker pen size. The patient surrogate was asked to lie in the same position for each participant, although the participant was able to adjust them as required. The same researcher measured the initial field and collected all replication size and displacement data, to ensure consistency in measurement. Each measurement was made to the same point, namely to the centre of the marked contour line.

Time was recorded from the end of the instructions being given to the radiographer indicating they were happy with their replication.

After each replication the researcher placed the gold standard Perspex mask on the patient surrogate, and measured the lateral and longitudinal diameters of the replicated outline, and the maximum lateral and longitudinal displacement from the gold standard (as illustrated in Fig. 6). A photograph was taken as a record of that individual replication, and the photograph number was recorded for later identification. The replicated outline was removed with an alcohol wipe suitable for use on the skin, so that it would not influence later replications.

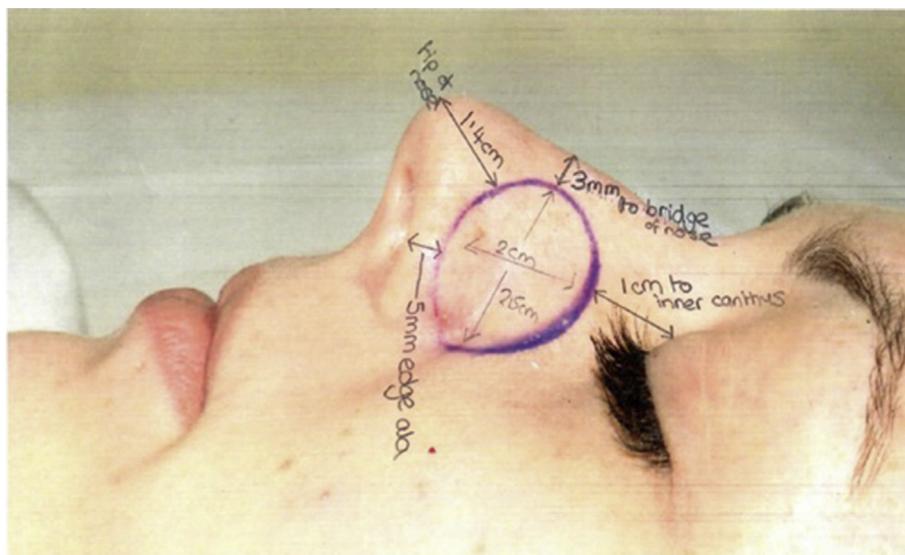


Figure 3. Method 3: Photograph plus measurements to anatomical landmarks.

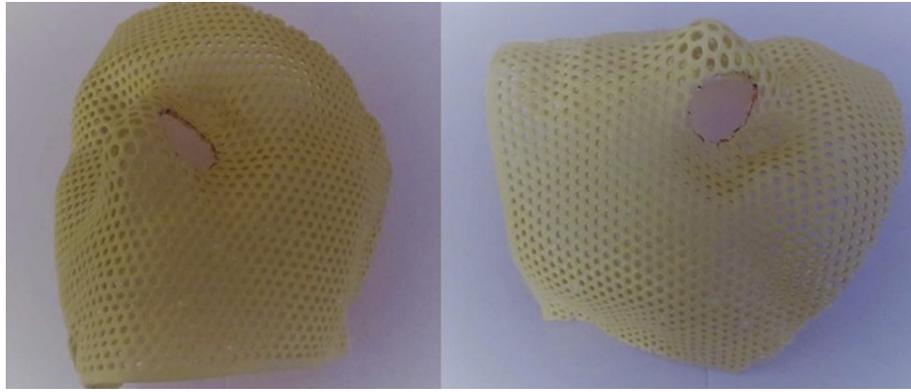


Figure 4. Method 4: A partial thermoplastic mask.



Figure 5. The gold standard Perspex mask overlaying a replicated outline.

The process was repeated by each participant using the remaining three replication methods, so that each participant had created the skin markings with all four methods.

After completing the study, each participant was emailed a short questionnaire to record their preferred replication method, and their level of confidence in each technique. The questionnaire consisted of mostly Likert scale and ordering type questions to achieve quantitative results and an open question for additional comments.

Data analysis

SPSS10 was used for the statistical analysis of the quantitative data collected for the ellipse area, lateral and longitudinal displacements, and replication timings.

Individual histograms for the data for each method were created, to ascertain if it was normally distributed or positively or negatively skewed so that the most appropriate type of test could be chosen.¹² Parametric ANOVA tests are designed to analyse data that fits a normal distribution¹³; where the data was not normally distributed, the Friedman test was used as it is regarded as the nonparametric equivalent of the parametric ANOVA.¹⁴

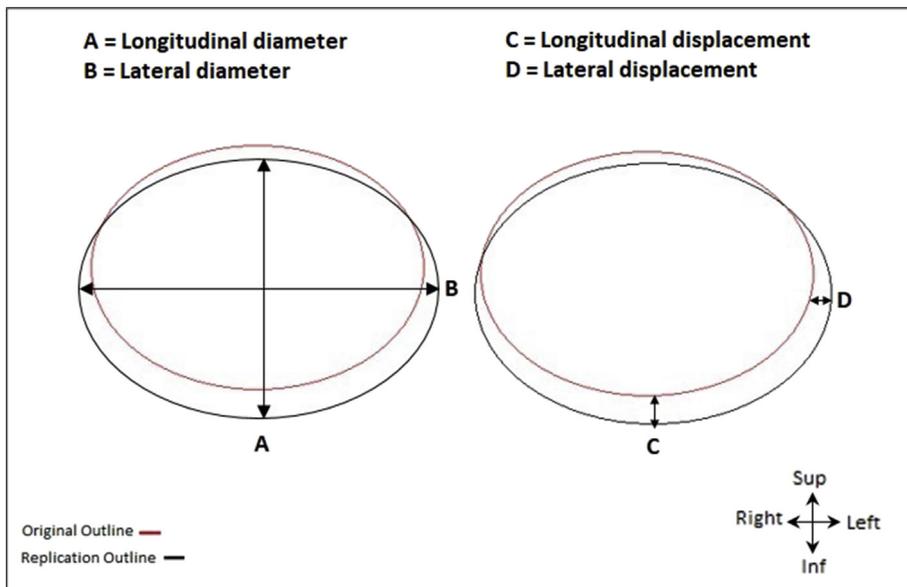


Figure 6. A schematic representation to illustrate the measurement of lateral and longitudinal diameters, and maximum lateral and longitudinal displacement from the gold standard.

The qualitative results from the Likert and ranking questions on user preference and confidence were analysed as a percentage of the radiographers. The open question for general comments was tabulated for analysis during the discussion.

Results

Ellipse area

As Fig. 7 illustrates, the mean ellipse area was comparable for all four methods suggesting there is no statistically significant difference in the means; the original ellipse created for this project was 2.0 cm by 2.5 cm with an area of 3.927 cm². For all four methods, the frequency histograms demonstrated a positively skewed distribution; a logarithmic transformation was applied to the data producing a normalised distribution.¹² A parametric one-way ANOVA test was used to investigate the statistical significance of differences in the mean areas.

As demonstrated in Table 3, the p-values of each comparison are greater than 0.05, with some approaching 1. Therefore there is no statistically significant difference in the mean ellipse area produced with the four replication methods.

Lateral displacement

Fig. 8 demonstrates there is overlap in the mean lateral displacement, from the gold standard, between methods 1, 2 and 4. Method three shares no overlap of frequency distribution with methods 2 and 4, suggesting there may be a statistically significant difference between the mean lateral displacements. Frequency distribution histograms for all four methods produced symmetrical,

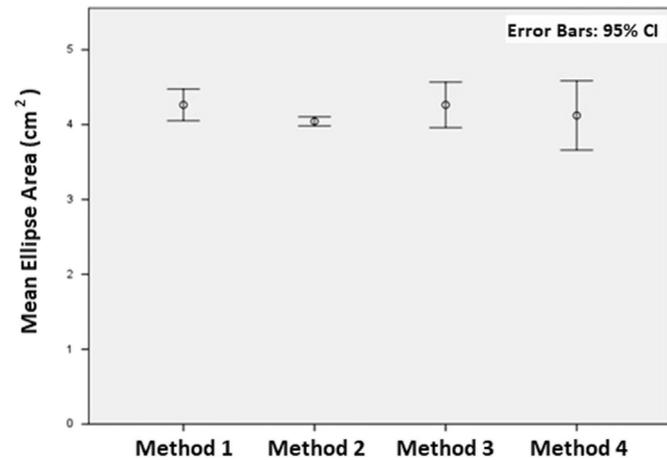


Figure 7. A comparison of the mean ellipse area for each of the four replication methods (Method 1: $\bar{x} = 4.263$ cm²; method 2: $\bar{x} = 4.043$ cm²; method 3: $\bar{x} = 4.263$ cm² and method 4: $\bar{x} = 4.121$ cm²). Error bars represent 95% confidence intervals.

Table 3

Comparing mean ellipse area for all 4 methods. Data normalised using logarithmic transformation and analysed with a parametric one-way ANOVA. $p < 0.05$ is significant.

Method	Mean ellipse area (cm ²)	Standard Error	Comparison of P-values			
			Method 1	Method 2	Method 3	Method 4
1	4.263	0.018	–	0.659	0.999	0.579
2	4.043	0.018	0.659	–	0.746	0.999
3	4.263	0.018	0.999	0.746	–	0.670
4	4.121	0.018	0.579	0.999	0.670	–

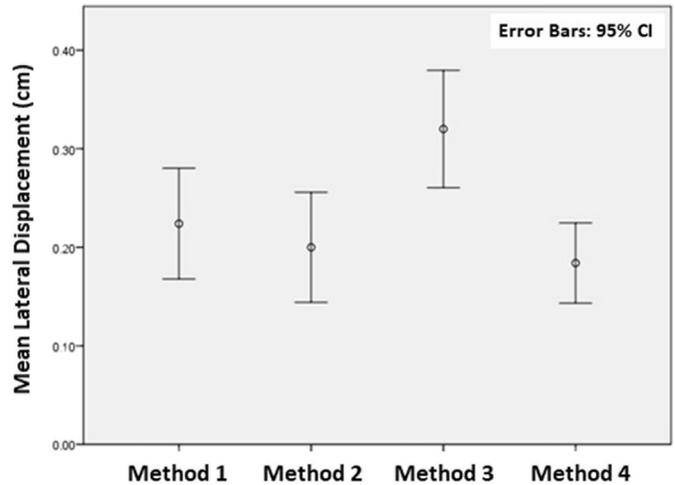


Figure 8. A comparison of the mean ellipse lateral displacement, from the gold standard, for each of the four replication methods. (Method 1: $\bar{x} = 0.23$ cm; method 2: $\bar{x} = 0.18$ cm; method 3: $\bar{x} = 0.32$ cm; method 4: $\bar{x} = 0.16$ cm). Error bars represent 95% confidence intervals.

normal distributions. It was therefore appropriate to perform a parametric ANOVA test on this data, the results of which are shown in Table 4. The results confirm that there are statistically significant differences in the mean lateral displacement, from the gold standard, between methods 2 and 3 ($p = 0.008$), and methods 2 and 4 ($p = 0.002$). The difference in mean lateral displacement, from the gold standard, between methods 1 and 3 is not as conclusive with a borderline p -value of 0.05.

In terms of maximum lateral displacement, from the gold standard, method 3 had the greatest displacement (0.6 cm) and method 4 the least (0.3 cm). Methods 1 and 2 demonstrated maximum lateral displacement of 0.4 cm and 0.5 cm respectively.

Longitudinal displacement

Fig. 9 demonstrates there is an overlap in the mean longitudinal displacement, from the gold standard, between methods 1, 2 and 4. Method 3 shares no overlap of frequency distributions with methods 2 and 4, and little overlap with method 1, suggesting there may be a statistically significant difference between the mean longitudinal displacements from the gold standard. Frequency distribution histograms for all four methods produced symmetrical, normal distributions; an ANOVA test on this data (Table 5), confirm that there are statistically significant differences between the mean longitudinal displacement, from the gold standard, of method 3, and that of methods 1, 2 and 4 ($p = 0.036$, $p = 0.000$ and $p = 0.000$ respectively).

In terms of maximum longitudinal displacement, from the gold standard, method 3 had the greatest displacement (0.7 cm) and method 4 the least (0.3 cm). Methods 1 and 2 demonstrated maximum lateral displacement of 0.5 cm and 0.4 cm respectively.

Table 4

Comparing mean lateral displacement for all 4 methods. Data analysed with a parametric one-way ANOVA. $p < 0.05$ is significant.

Method	Mean Lateral Displacement (cm)	Standard Error	Comparison of P-values			
			Method 1	Method 2	Method 3	Method 4
1	0.23	0.037	–	0.914	0.050	0.694
2	0.18	0.037	0.914	–	0.008	0.972
3	0.32	0.037	0.050	0.008	–	0.002
4	0.16	0.037	0.697	0.972	0.002	–

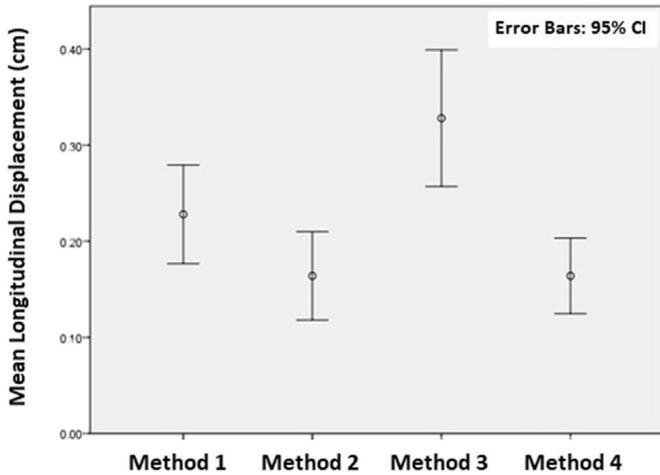


Figure 9. A comparison of the mean longitudinal displacement, from the gold standard, for each of the four replication methods. (Method 1: $\bar{x} = 0.22$ cm; method 2: $\bar{x} = 0.16$ cm; method 3: $\bar{x} = 0.33$ cm; method 4: $\bar{x} = 0.16$ cm). Error bars represent 95% confidence intervals.

Time: efficiency

As Fig. 10 illustrates, method 3 demonstrates the greatest mean amount of time for replication. Methods 2 and 4 were completed in the least time, and demonstrate similar variation in the mean time taken. The greatest variation between minimum and maximum time taken was recorded for method 3, as shown in Table 6.

Data for the mean time taken showed a variety of frequency distributions between the four methods when represented as

Table 5
Comparing mean longitudinal displacement for all 4 methods. Data analysed with a parametric one-way ANOVA. $p < 0.05$ is significant.

Method	Mean Longitudinal Displacement (cm)	Standard Error	Comparison of P-values			
			Method 1	Method 2	Method 3	Method 4
1	0.22	0.036	–	0.301	0.036	0.301
2	0.16	0.036	0.301	–	0.000	1.000
3	0.33	0.036	0.036	0.000	–	0.000
4	0.16	0.036	0.301	1.000	0.000	–

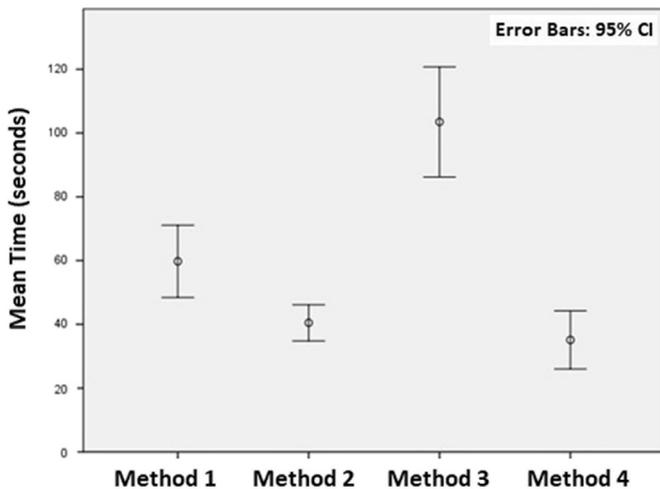


Figure 10. Mean time taken to complete each replication for each of the four methods, in seconds (Method 1: $\bar{x} = 59.76$; method 2: $\bar{x} = 40.48$; method 3: $\bar{x} = 103.48$; method 4: $\bar{x} = 35.12$). Error bars represent 95% confidence intervals.

Table 6
The mean, minimum and maximum time taken to complete a replication of the treatment field for each of the four methods.

Method	Mean Time Taken (Seconds)	Minimum Time Taken (Seconds)	Maximum Time Taken (Seconds)
1	59.76	20.00	140.00
2	40.48	18.00	70.00
3	103.48	25.00	209.00
4	35.12	14.00	129.00

frequency histograms; as the data could not be normalised, the non-parametric Friedman test was performed to ascertain the statistical significance of the differences; a p-value of 0.000 from this test indicates there was statistical significance between the time taken for the four methods.

User preference and confidence

Quantitative data

25 radiographers carried out the practical section of the study, of these 22 completed the self-administered online questionnaire. The user preference for each method was recorded in rank order (Fig. 11); method 2 was the most favoured (47.6%), closely followed by method 4 (41.0%). Method 3, the photograph and measurements alone, was ranked as the least favourite (72.7%).

User-confidence in the replication method was recorded using a Likert scale (1–10), where 1 was not confident and 10 extremely confident. Methods 2 and 4 were reported as instilling the most confidence, with twenty out of the twenty-two radiographers indicating a confidence level of 7 or above for these methods. Eighteen radiographers indicated confidence level of 7 or above for method 2, and only seven for method 3. This is demonstrated in Table 7, where the median user-confidence for methods 2 and 4 are recorded as 9, and 5 for method 3.

Qualitative data

An open question was added at the end of the questionnaire, giving the radiographers an opportunity to leave any comments. Eleven radiographers commented on the study, and these are presented in Table 8. Further comments that have not been included in the table were of a supportive nature to the study. If the research was to be repeated, this open question could be made more specific to reporting comments on the methods. A pilot questionnaire was not carried out for this study, which may have highlighted this limitation.

Discussion

Although there was no statistical significance in the difference between mean areas replicated, all four methods produced contours larger than the original treatment field area. The study team acknowledges that the positively skewed data suggests a systematic over-estimation of the treatment area; however, no obvious explanation is apparent or forthcoming from the participant comments, and we concede that this may be a source of future investigation. In clinical practise, the area is defined by the end of the applicator or the lead cut-out, therefore the area of the treatment field delivered should always be correct. However, if the replicated outline is larger than the applicator or cut-out, the radiographer must make a judgement on where to place it within that outline. This may lead to a random geometric setup error if placed incorrectly, with the risk of systematic error if repeated for further fractions. The treatment set-up was not investigated as part of the study; the study was evaluating the methodology for replicating

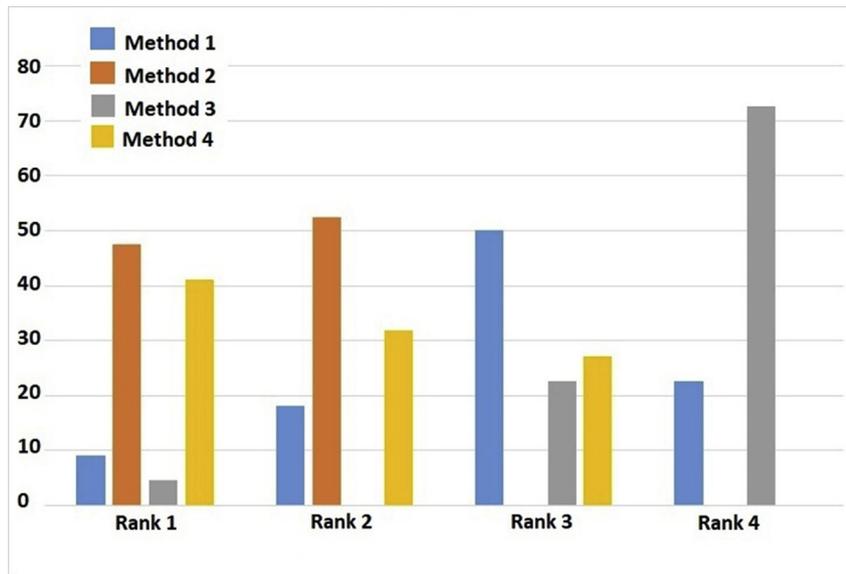


Figure 11. Ranked user-preference of the replication method, where 1 is the most preferred and 3 the least preferred. The results are displayed as a percentage of the total number of radiographers.

treatment marks, and it is proposed that the variation in set-up from those marks is not technique specific.

Method 3, the photograph with measurements to anatomical landmarks, produced the largest displacements both laterally and longitudinally. These displacement were statistically significant when compared to each of the three other methods. This was a counterintuitive result as it is the only method which included specific measurements rather than solely relying on visual judgement. However, it must be remembered that the measurements were taken from the 3-dimensional features of the patient, and

Table 7

The median user-confidence reported by radiographers for each of the four methods using a Likert scale, where 1 is the least confident and 10 the most confident.

Method	Median User-Confidence (Likert scale 1-10)
1	8
2	9
3	5
4	9

then translated on to a 2-dimensional photograph, introducing a level of subjectivity. This was further supported by method 3 scoring the least preferred and instilling the least confidence of all the methods. Several radiographers wrote comments on the subjectivity of this method, and their lack of confidence in its accuracy. For example, one radiographer commented “The measurements on the photograph can be interpreted very differently, as they are subjective”. This may explain the statistically significantly longer time taken for method three; a lack of confidence in the technique may result in radiographers taking more time for replication and subsequent assessment.

The maximum individual displacements (laterally: 0.6 cm; longitudinally; 0.7 cm) recorded during the study exceeded the 0.5 cm CTV margin that is recommended as a standard for BCC.⁴ In the context of other clinical research which suggests that current margins may be conservative,⁸ these displacements would be considered clinically significant.

Replications using method 4, the partial thermoplastic mask, took the least mean time, and scored highly for both preference and confidence. A high level of confidence in a technique could lead to a false sense of security and an over-reliance in its accuracy. Method

Table 8

Comments given by radiographers in the online questionnaire.

I found using the thermoplastic shell to be very comfortable as it enabled me to use two hands to mark on as it held itself in place. It felt more comfortable and accurate. As with any procedure the key is the experience and care taken by the operator. I am confident with all of the techniques as I have the experience of all of them. The partial thermoplastic mask technique will be dependent on very careful fitting of the mask and may lead to a false sense of security if used. All have room for error if care is not taken and a photo is always necessary to help with accurate reproduction. Replication techniques: Measurement technique very subjective. Thermoplastic mask, rough edges of mask distort field shape when tracing. Personally, I felt acetate plus photograph was more accurate. Study: Marking up the same area for each technique can be slightly leading as you know what to expect (in terms of location and field size). However, marking up the same area is the most reliable for an accurate comparison. Generally from experience they are all useful methods. I'd say the photograph as reference only would be the least accurate of the 4. Interesting study. Think the acetate alone can move when you bend it to mark on the patient and the anatomical reference points can be very subjective. This may lead to variation in treatments between fractions. I feel that having a photograph/diagram with measurements alongside one of the other replication techniques would be preferable to ensure accuracy. The study was very interesting to participate in, I did feel that marking up the same area four times was potentially leading, making it easier to complete the task each time, despite the technique used. The measurements on the photograph can be interpreted very differently, as they are subjective. The partial mask is a good way of transferring marks, as long as it is a good fit. Accuracy can also be dependent on visibility of surgical scar and on location as well (i.e. where on the body we are marking up). Generally speaking, surfaces that are not flat (e.g. the nose in particular) tend to be harder to mark up. Also, on the acetate given for this study, features like the mouth were not drawn on which I think would improve the accuracy slightly (more to match on).

4 resulted in the smallest maximum displacement (0.3 cm) in both lateral and longitudinal directions; any displacement may have been caused by a difference in pressure when holding the mask on to the patient or the lack of a smooth outline created when the thermoplastic mesh is cut to the treatment field, as indicated by radiographer questionnaire comments.

It is interesting to compare the results for method 1 (the acetate sheet) and method 2 (the acetate sheet with tracing holes). The largest difference in the two techniques was in user preference and confidence, where method 2 scored much higher than method 1. The mean time taken using method 1 was longer than that of method 2 (59.76 s compared to 40.48 s). There was no significant difference in the size or displacement of the outline when replicating with methods 1 and 2, however it is likely that method 2 was faster as it is more straightforward to place on the patient and trace through, rather than repeatedly lifting and replacing the plain acetate sheet.

Limitations of the study are acknowledged. Notably, this study was limited to one clinical site and a maximum number of radiographers. To have further confidence in the results, it should be repeated on a larger scale involving different centres and a larger number of radiographers. Although responses to the questionnaire suggested the majority of radiographers had previously used most of the methods, there may still be a bias towards techniques used in that centre that would be avoided if multiple centres were studied. If the study was to be repeated in the future, it may also be of use to ask the radiographers how they decided on where to mark. An additional limitation given the experimental nature of the project is the lack of an actual tumour/scar on the patient surrogate which could possibly guide treatment placement. However, we would caution that as initial skin landmarks may change during the course of treatment, using these as a basis for the treatment area may be misleading.

Although bias was minimised by randomly allocating the method order, it would be preferable the radiographer did not perform serial replications with different methodology during the same session. It would also be preferable to use different tumour locations to avoid replication familiarity with each methodology. In addition, replications could have been repeated multiple times by the same radiographer on subsequent days to quantify intra-user consistency. These preferences were not possible in this study due to time constraints on the patient surrogate and the radiographers that participated, and the availability of a clinical treatment room.

Although not part of the study design, the surrogate patient reported that they greatly preferred method 3 as a technique. The patient surrogate felt that the other methods were more invasive of their personal space, as they involved both something being placed on their face and having the radiographers' hands touching their face. Even when using a metal ruler to measure to delicate areas such as the inner canthus, the patient felt more comfortable with this brief interaction, than with the prolonged contact with the other methods. This is in complete contrast to the preferences reported by the radiographers. It is possible that when concentrating on replicating the field outline, the radiographers become task focused and lost awareness of how they were interacting with the patient. As the patient surrogate was a single radiographer, meaningful qualitative data could not be extracted; further studies could investigate the various methods from a patient perspective.

Conclusions

The aim of this research was to evaluate the accuracy and time-efficiency of these replication techniques. Method 3 was found to be the least accurate, the most time consuming, and least

preferred by users. As the second most commonly used replication method in the UK, this warrants further research for its use. There was no statistically significant difference in the accuracy or time-efficiency of methods 1, 2, and 4, indicating that extra 3-dimensional information is valuable. However, methods 2 and 4 were reported as instilling the most confidence and preferred by the radiographers. Therefore, overall methods 2 and 4 are the preferable techniques to use.

The clinical significance of these results will depend on the margins used in local practise. Further research into most appropriate GTV to CTV margins for superficial radiotherapy, and clarification of any margin allowing for set-up error (PTV), would provide more confidence that all microscopic tumour is within the treatment field.

The method of leaving marks on the patient throughout treatment was excluded as being inconsiderate for the patient, and disregarding their right to confidentiality if in a visible area.

However, if the patient feels that methods that involve excessive contact with the face are intrusive, this should also be taken into consideration in order to provide patient-centred care. Further research into patient preference needs to be carried out in order to assess whether this is an accurate representation of the opinion of NMSC patients.

Conflicts of interest

The authors have no conflicts of interest.

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