WELLINGTON BLOOD AND CANCER CENTRE

Dosimetric impact of catheter stretch during multi-catheter interstitial breast brachytherapy

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Background

- In 2016 WBCC initiated a pilot project to treat 10 patients with HDR multi-catheter interstitial breast (MCIB) BT

→ ***To collect data to determine the long-term feasibility of the technique at WBCC***

Treatment overview

→ 34Gy in 10 fractions or 32Gy in 8 fractions

→ First treatment day: catheter insertion under U/S and C-arm guidance, CT, planning and fraction 1

→ Subsequent fractions: bi-daily

→ Catheter removal: following the final treatment

Catheter length checks

ICRP recommends total internal applicator length measurements prior to each fraction

→ Our initial experience of internal applicator length measurements showed that the Nylon 6/6 treatment catheters used in our centre appear to stretch over a patients 5-8 day treatment course

→ ***We conducted a study to assess the clinical impact of this***

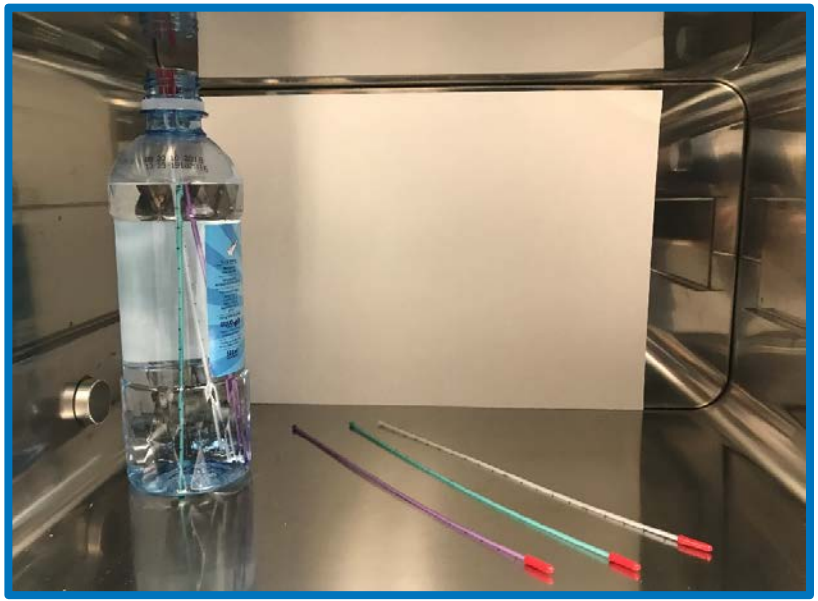
Study Aims

1. Evaluate the magnitude of catheter stretch during a course of MCIB
    - Investigating internal length change when exposing catheters to moisture and heat
    - Analysing the catheter stretch observed over the treatment course of 7 patients

2. Assess the dosimetric impact of catheter stretch
    - Applying the measured stretch seen in water and patients to treatment plans

Applicator Internal Length Measurements in Water

- Nylon 6/6 catheters exposed to 37°C water
- Internal length measurements at 2 hours, 4 hours, 24 hours and every 24 hours thereafter for 120 hours



Baseline Treatment Plans

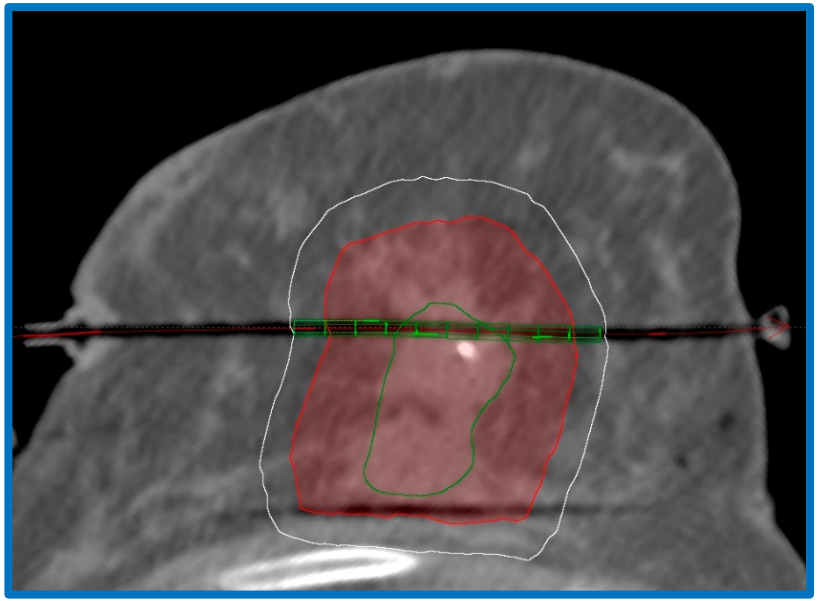
- Retrospective plans (P_R) created

→ Single planner to ensure consistent plan quality

→ Initial pre-planning length measurements used

→ 0.5cm expansion on CTV (dwell volume) used to activate and determine dwell positions

→ Volume optimisation and dose shaper to create clinically acceptable plans



Dwell positions with one catheter are shown with the dwell volume which is used to set the dwell positions

Planning Aims

Structure	Objective
$D90_{CTV}$ (%)	≥ 100
$V100_{Body}$ (cm^3	< 150
$V150_{Body}$ (cm^3)	< 50
$V200_{Body}$ (cm^3)	< 20
DNR (dose-non-uniformity ratio)	< 0.35
$D0.2cc_{Skin}$ (%)*	< 100
$D0.1cc_{Ribs}$ (%)	< 90

*Skin was defined as a 0.5cm internal margin structure from the skin surface

Application of catheter stretch to P_R

1. Average maximum length change seen in the catheters exposed to water (*ΔL_W*) was applied to each catheter in the P_R ($P_{\Delta L\_W}$)

   → *Applied as a % based on the length of each catheter inside the breast tissue*

2. Maximum length change (*ΔL_P*) for each catheter over each patients course was applied to the P_R ($P_{\Delta L\_P}$)

3. Dosimetric changes to CTV coverage, DNR (V_{150}/V_{100}) and OAR were analysed

Results

Applicator length measurements in water

Time	Average ΔL_W (15cm exposed)	
2 hours	+ 0.2cm	1.3%
24 -150 hours	+ 0.6cm (range 0.5-0.7cm)	4.0% (range 3.3-3.7%)
	ΔL of reference catheters (in air at 37°C and 22°C)	
2-150 hours	+/- 0.1cm	

→ On average remaining the same for the rest of the time

Results

Applicator length measurements in patients

→ Average ΔL_P after the second treatment day = +0.2cm (0-0.4cm), and remained, on average the same during the treatment course

→ Average catheter length within tissue = 12.3cm (8.1-17.4cm), assuming all of the catheter stretch occurred within the “in tissue” section, the maximum stretch was on average 1.6%

→ Maximum stretch of 0.4cm was seen in 5 of 76 catheters

Results

Catheter stretch applied to treatment plans

	Objectives	P_R	$P_{\Delta L\_P}$	$P_{\Delta L\_W}$
$D90_{CTV}$ (%)	≥ 100	101.1 ± 6.0 (90.2-109.4)	99.6 ± 5.3 (89.9-107.1)	92.9 ± 3.9 (83.9-97.0)
$V100_{Body}$ (cm^3)	< 150	82.0 ± 32.0 (43.2-137.3)	81.9 ± 32.0 (43.2-137.0)	81.6 ± 30.7 (47.1-141.0)
$V150_{Body}$ (cm^3)	< 50	29.1 ± 10.4 (15.7-45.7)	29.4 ± 10.8 (15.7-46.7)	29.0 ± 10.2 (14.8-46.6)
$V200_{Body}$ (cm^3)	< 20	11.7 ± 4.1 (6.2-18.5)	11.7 ± 4.2 (6.2-18.9)	11.5 ± 3.9 (6.0-18.3)
DNR	< 0.35	0.36 ± 0.07 (0.30-0.49)	0.36 ± 0.07 (0.30-0.48)	0.36 ± 0.06 (0.29-0.48)
$D0.2cc_{skin}$ (%)	< 100	84.2 ± 16.6 (51.9-102.8)	83.2 ± 16.0 (54.5-104.0)	82.4 ± 16.6 (55.3-111.5)
$D0.1cc_{Ribs}$ (%)	< 90	69.1 ± 20.0 (34.7-89.0)	68.0 ± 19.9 (33.4-88.0)	67.3 ± 18.9 (33.4-87.8)

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→ Average $D90_{CTV}$ decreased by 1.5% ($p < 0.05$) for $P_{\Delta L\_P}$ and 8.2% ($p < 0.05$) for $P_{\Delta L\_W}$ when compared to P_R

→ For 1 patient the $D0.2cc_{skin}$ objective was exceeded by the initial plan at 102.8%, this increased to 104.0% and 111.5% for $P_{\Delta L\_P}$ and $P_{\Delta L\_W}$, respectively

→ All other OAR remained within tolerance

Discussion

→ On average, 4.0% length increase seen when exposed to water and 1.6% increase during HDR MCIB BT

→ Maximum stretch seen *in vitro* was reached faster than that for patients (24 hours vs 48 hours)

→ Stretch seen in the catheters inserted into patients is relatively smaller than *in vitro* measurements

Why does the Nylon 6/6 stretch?

→ Nylon 6/6 is hygroscopic and moisture absorption can lead to an increase in dimensions of up to 3%

→ In addition to moisture absorption, mechanical tension might also be present on the treatment catheters during a treatment course

GoodFellow: Material information for Polyamide – Nylon 6,6 (PA 6,6). Available at: http://www.goodfellow.com/E/Poly amide-Nylon-6-6.html [Accessed: 15 March 2017].

Impact on Clinical Practice/Recommendations

→ Dwell volume = 0.5cm CTV expansion resulted in dwell positions ≥0.25cm outside the CTV to *improve robustness for catheter inter-fraction variation and stretching*

- A tighter dwell volume would most likely result in a larger dose reduction

→ 1.5% dose coverage reduction is not significant however a 8.2% reduction may have a clinical impact and could be possible at centres where the catheters are measured only immediately after the insertion

- *Additional length checks during APBI HDR Brachytherapy are recommended and applicator lengths can be adjusted accordingly*

→ Usual tolerance = ± 0.1cm, *adding an additional 0.1cm to the length of each catheter is justified by the average catheter stretch of 0.2cm* → the variation from the planned length will usually fall within 0.1cm

Study Limitations

→ Maximum ΔL_P per catheter introduced to the initial plans and assumed for all fractions

→ Unknown whether the catheter stretch occurs evenly over the full catheter length inside tissue or is dependent on other functions of the implant such as the seroma site

→ Positional displacement of catheters due to seroma changes, tissue deformation, or inflammation, were not included in the dosimetric analysis

Serial CT imaging over a patients' treatment course, as well as details on catheter stretch are needed to determine the full dosimetric impact of inter-fraction variation with MCIB BT

Conclusion

→ Nylon 6/6 catheters stretch when exposed to water and during a course of HDR MCIB BT

→ Length increases were shown to have a minor dosimetric impact in clinical cases when a 0.5cm dwell volume expansion was applied to treatment plans and the initial length measurements were completed 2 hours after catheter insertion

→ We propose reducing the already small dosimetric impact of catheter stretch by adding an additional 0.1cm to the applicator length in the treatment plan

→ In institutions where catheters are cut to a known length immediately after insertion or the length measurements are only done immediately after the insertion, the catheter stretch may have dosimetric impact and additional length checks are recommended

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Thank you

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References

1) Boman E, Paterson D, Hons BRT, Huang J, Pearson S, Johnson C, et al. Treatment plan dosimetric impact after catheter stretch during multi-catheter interstitial breast brachytherapy. J Contemp Brachytherapy. 2017;9(5).