Clinical Oncology (2007) **19:** 655–660
doi:10.1016/j.clon.2007.07.005

Overview

Comparison of 50 kV Facilities for Contact Radiotherapy

C. L. Fletcher, J. A. Mills, G. M. Baugh, J. Roughton

Department of Clinical Physics and Bioengineering, University Hospital, Coventry, UK

ABSTRACT:
The radiation characteristics of a short source to surface distance (SSD) contact therapy tube in clinical use at the Centre Antoine-Lacassagne, Nice and a long SSD unit at the Clatterbridge Centre for Oncology were compared. The output from the tube at Nice had a dose rate of approximately double that of the tube at Clatterbridge, whereas the tube at Clatterbridge had a slightly higher value of the half value layer. Depth dose measurements were made with GafChromic MD55 film and SSD corrected depth dose curves showed good agreement between centres. Profiles at 2 mm depth also showed comparable levels of flatness and uniformity. Fletcher, C. L. *et al*. (2007). *Clinical Oncology* 19, 655–660

Key words: Contact radiotherapy, papillon technique, radiochromic film, rectal cancer

Introduction

Contact therapy is an established technique using X-rays with a half value layer (HVL) of about 0.5 mm Al at a short source to surface distance (SSD) of typically 2 cm [1,2].

It is currently carried out using the Phillips RT 50 contact therapy unit, which is no longer manufactured and was designed more than 30 years ago. Alternatively, existing low-energy X-ray machines at a long SSD are being used, as there is no dedicated short SSD unit commercially available.

Here we describe the measurements used to compare the radiation characteristics of two existing contact therapy units.

Materials and Methods

The characteristics of beams in clinical use at the Centre Antoine-Lacassagne, Nice, France and the Clatterbridge Centre for Oncology, Clatterbridge, UK were compared. The characteristics and running parameters of the tubes are given in Table 1. The tube at Clatterbridge is a low kV therapy unit adapted to use the long SSD technique, whereas the contact therapy unit at Nice is a specialist short SSD RT50 Philips machine.

The following measurements were made: dose rate, HVL, central axis depth dose, uniformity and flatness.

Dose Rate

Dose rate measurements were made using a PTW 0.02 cm^3 soft X-ray chamber type 23342 and a Farmer-type electrometer NE 2670.

In order to measure the dose rate, the PTW soft X-ray ion chamber was positioned directly at the end of the applicator and five 60 s time of flight readings were taken.

Half Value Layer

The HVL was measured by determining the thickness of aluminium absorber needed to reduce the radiation beam intensity by 50% for a narrow beam geometry.

The radiation beam was directed vertically downwards using a plumb bob and a lead collimator was placed centrally in order to define a narrow beam. The soft X-ray ion chamber was clamped centrally within the radiation beam at 50 cm SSD.

Sheets of aluminium filtration of 0.05 mm thickness (99% purity) were added progressively into the beam and measurements were taken for 60 s exposures. The results were taken in duplicate and the entire measurement, including the set-up, repeated in order that an average HVL could be found. The percentage transmission of X-rays against the thickness of aluminium was used to determine the HVL.

Central Axis Depth Dose

The measurement of depth dose curves for kV X-ray beams is difficult and usually not very accurate, especially near the surface. Problems are related to large gradients in the dose distribution and the large energy dependence of most dosimetry systems [3].

Cylindrical chambers have a reasonably energy-independent response, but measurement depths are limited to no less than the outer radius and so they are not suitable for

Table 1 — Details of the contact therapy machines measured

Centre	Contact therapy machine	Applicator size (cm)	SSD (cm)	kV	mA	Filtration
Nice	Phillips RT 50	3	4	50	n/a	0.5 mm Al
Clatterbridge	Pantax Therapax 3 with rectal applicator	2 2.5 3	28	50	45	0.4 mm Al

SSD, source to surface distance.

surface measurements. Ma *et al*. [4] suggested caution when using chambers with significant bodies. However, diodes have been found to need a perturbation correction factor [5] and have a significant beam quality dependence.

Li *et al*. [6] used radiographic film in a study of different dosimeters for measuring kV percentage depth dose and field profiles. The measurements gave incorrect profile tails for low energy and a low dose level area outside the field. Although there are no published results for using radiochromic film for percentage depth dose measurements at this energy, GafChromic MD55-2 film has been found to have a lower energy dependence than radiographic film [7] and was chosen for measuring and comparing percentage depth dose curves.

The central axis depth dose was measured using MD55 GafChromic film in a purpose built solid water phantom made of WT1 material. MD55 GafChromic film consists of a thin, colourless transparent coating of a polycrystalline-substituted diacetylene sensor layer on a clear polyester base [8].The film was exposed parallel to the incident radiation in a solid water phantom, attached to the end of the applicator so that the surface was at the minimum possible SSD. Two films were each given an exposure of about 60 Gy.

The use of radiochromic film as a dosimetry system is advantageous because it has low spectral sensitivity and gives very high spatial resolution, which is especially useful in regions of high dose gradient. It requires no special development procedure and is therefore quick and easy to use. The radiochromic reaction is a solid state polymerisation [8] and the film responds to ionising radiation and ultraviolet light by progressively turning blue, with two

Table 2 — Average output measurements

	SSD (cm)	Dose rate (Gy/min)	Standard deviation (%)
Nice Phillips RT 50	4	14.90	0.8
Clatterbridge Pantax Therapax 3 with rectal applicator	28	8.12	0.1

SSD, source to surface distance.

Table 3 — Measured values of half value layer (HVL)

	HVL (mm Al)	Standard deviation (%)
Nice Phillips RT 50	0.32	12.3
Clatterbridge Pantax Therapax 3 with rectal applicator	0.40	2.4

distinct absorption bands at wavelengths of 695 and 610 nm. The intensity of the blue colour is a measurement of the absorbed dose.

Colour formation continues at an ever-decreasing rate after exposure, depending on the absorbed dose and the storage temperature. The exposed film was read at 24 h after exposure as relatively little change in colour density occurs after this time [8].

Each exposed film was scanned using a Vidar film scanner and analysed using the PTW MePhysto mc^2 film analysis software in order to determine the central axis depth dose in 0.5 mm steps. These data were exported to Excel and processed to create an average central axis depth dose profile for each tube.

To account for non-linear film response a film dose response look up table was created using films exposed to different doses in a 6 MV photon beam. Because of the relative energy independence reported for GafChromic film [9] this look up table was applied to the 50 kV films to convert the scan intensities into a relative dose.

Suchowerska *et al*. [10] found that radiochromic film has an over-response when exposed parallel to the central axis due to an air gap. The solid water phantom was designed to minimise this over-response by ensuring that an air gap is not introduced.

The validity of using GafChromic film was investigated by comparing percentage depth dose measurements for a 50 kV beam on a Gulmay medical D3300 DXR unit using several devices. The depth profiles were normalised at 2 cm depth and agreed to ±7.5% between 10 and 30 mm from the

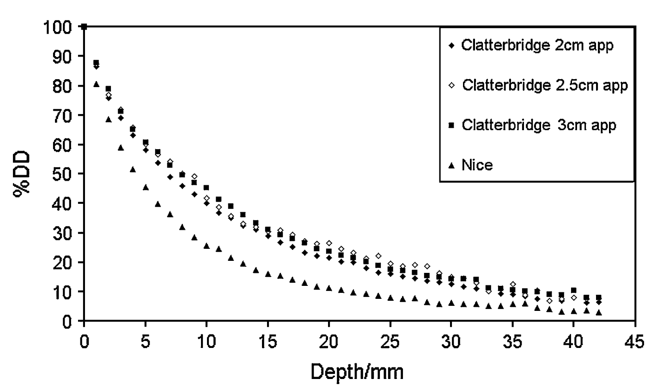

Fig. 1 — Central axis depth dose profiles from different centres, source to surface distance uncorrected.