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DOSIMETRIC VERIFICATION OF VERTICAL-TYPE SURFACE APPLICATORS USING A FARMER-TYPE IONIZATION CHAMBER FOR HIGH-DOSE-RATE ^{192}IR BRACHYTHERAPY: TREATMENT OF SKIN CANCER

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Abstract

Purpose: This study aims for output verification and to validate the dosimetric performance of Varian vertical-type surface applicators using a Farmer-type ion chamber for high-dose-rate (HDR) ^{192}Ir brachytherapy. **Materials and Methods:** Varian's vertical-type surface applicators are used at two different dwell positions (d.p) with the source center located at -10 mm and at -15 mm from the centre of first nominal dwell position. Measurements are performed using a Farmer-type ion chamber at 5 mm depth and compared with vendor data and TPS generated values. Relative dosimetry using gafchromic film was performed at 4 mm depth in phantom. The therapeutic area was determined as a full width at 90% dose level. **Results:** For d.p -15 mm, the measurements showed 9% agreement with vendor data and 5% with TPS calculations. The smallest applicator, SA10, showed poor agreement (percent difference ~14%) compared to vendor data. For the d.p -10 mm, the result reveals the reduced agreement; 13% with vendor data and 6% with TPS calculations. The results from full width measurement at 90% dose level agreed within 2 mm with vendor data and 3 mm with TPS values. The PDD curves showed good agreement for both the vendor data and TPS predictions. **Conclusion:** This study demonstrates an easy, simple and independent way to verify the output dose measured with Leipzig-style, Varian vertical-type surface applicators. The results validate the performance of these applicators for accurate dose delivery and the treatment of skin cancer, ultimately improving the quality of work and patient care.

Keywords: Surface Applicator, Farmer Ion Chamber, Dosimetry, HDR Brachytherapy, Ir-192 Source, Percent Depth Dose, Skin Cancer

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1. INTRODUCTION

Skin cancer is a very common disease, mostly cured by surgery. A few cases of skin diseases are preferred to be treated with radiation therapy for the patient's health, tumour position, and better cosmetic results. Skin cancer has become one of the most serious and common types of cancer, claiming the lives of 80,000 people each year [1]. The death rate in Pakistan, due to skin cancer is 0.40 out of 1,00,000 with an average increase of 1.2% a year [2]. Skin cancer is classified into three types: basal cell carcinoma (BCC), squamous cell carcinoma (SCC), and melanoma [3]. The first two types together are known as non-melanoma skin (NMS) cancer (also called Keratinocyte carcinoma, KC), which mostly arises from the epidermal layer of the skin [4]. If detected in an early stage, non-melanoma skin cancer can be cured or at least managed more efficiently by using radiation therapy [5]. The primary concerns when treating skin cancer are dose homogeneity, which conforms to the required treated area, and skin sparing for the surrounded healthy tissues. The surface dose and the dose beneath the tumour should be justified and kept as low as possible. HDR ^{192}Ir brachytherapy sources are common in use as a radiation therapy modality to deliver an accurate and uniform dose to skin lesions or skin cancer, controlling the dose to healthy tissue at a minimum level [5]. Dedicated surface applicators for superficial treatment have been developed, which can easily be used with ^{192}Ir HDR brachytherapy to achieve the therapeutic goals in cases of skin lesions and skin cancers.

Generally, the choice of surface applicator selection concerns the clinical assessment of skin lesions, treatment margins, and radiation source. Typically, a conical surface applicator intended for use with a radionuclide-based source, is used at a single dwell position positioned either parallel or perpendicular with respect to the skin surface. Superficial lesions are most commonly treated with a depth ranging from 3 to 5 mm, delivering 5-7 Gy per fraction on the basis of diagnostic imaging and clinical investigations. Using radionuclide-base applicators, the brachytherapy is commonly scheduled as 42 Gy/6 fractions, 42 Gy/7 fractions, or 40 Gy/8 fractions on alternate days or twice weekly. Guidelines for patient selection, dosimetry, and dose/fractionation for the treatment of skin cancer presented in the ABS consensus statement, Shah et al.-2020 [6] were reviewed. For large lesions (d ≥ 50 mm), a planar applicator with a set of plastic catheters implanted in' or fixed to a tissue-equivalent plastic (e.g. a flap applicator) is commonly used [7].

Currently, Nucletron—an Elekta company, (Veenendaal, Netherlands) and Varian Medical Systems (Palo Alto, CA, USA) are the two manufacturers fabricating the conical-type surface applicators used with the HDR ^{192}Ir source. Nucletron (Elekta) offers two sets of conical surface applicators, marketed as (i). Leipzig H-type and V-type applicators come in three diameters: 10, 20 and 30 mm with a nominal SSD of 16 mm. Each applicator has a 1.1 mm plastic treatment cap to lessen the secondary-electron contamination originating from the inner side of the cone wall, and (ii). The Valencia applicator set consists of only two applicators having diameters of 20 and 30 mm. Valencia applicators are similar to Leipzig H-type applicators but have a flattering filter

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attached to the exit window to ensure dose uniformity and flatness on the skin surface [8]. Varian offers two types of radionuclide-based Leipzig-style conical surface applicators manufactured using stainless steel and tungsten alloy. One applicator set is the horizontal (H) type and is marketed to be used with GammaMed and VariSource series brachytherapy remote afterloaders. The other set is the vertical (V) type and intended only for the GammaMed series afterloaders. In an H-type applicator, the source can be positioned parallel to the target skin inside a built-in steel source guide tube (SGT) with a 12.5 mm source-to-surface distance (SSD). In a V-type applicator set, the source axis is perpendicular to the skin surface inside a 114 mm vertical source guide tube with an SSD of 2 mm approximately. In contrast to Elekta applicators associated with treatment caps or filters, the Varian surface applicators are offered with a thin polycarbonate window fixed at the distal side of the applicator insert, which assists in ensuring contact between the applicator and the treatment surface.

The recommendations of AAPM TG-43 for brachytherapy sources were used to calculate the dose profiles for different applicators at a depth of 0.5 cm beneath the skin surface [9]. The QA procedures for Nucletron marketed H-type Leipzig-shape surface applicators and Valencia applicator sets intended for use with HDR brachytherapy ^{192}Ir sources carried by Pérez-Calatayud *et al.* [10] were also considered as literature for the current study. A number of studies regarding Leipzig-style applicators concluded that these applicators may be used as a substitute for electron beam therapy if a comparatively thin plastic cap is attached to its exit window to absorb electron contamination, hence to minimize higher doses at the surface [11-14].

Sebastian Sarudis [12] studied the dose distribution profile under the Leipzig-style surface applicators and reported a mean difference between the TG-43 and Monte Carlo of 1.25 % for the horizontal applicators and 2.11 % for the vertical-type applicators. Iftimia *et al.* [15] validated the dosimetric performance of the vertical-type Varian surface applicator taking measurements at 5 mm depth in a solid water (SW) phantom, and concluded that the results were within 10% agreement. In-air measurements were also taken for each applicator at its surface, with the conclusion of a 4% difference as compared to vendor data. The current study is intended to evaluate an independent useful methodology for the verification of dose output from vertical-type surface applicators used in brachytherapy clinical practice.

2. MATERIALS AND METHODS

2.1 HDR Source, Surface Applicators, and Commissioning Considerations

Brachytherapy afterloader unit (Varian Medical Systems, Palo Alto, CA) loaded with HDR ^{192}Ir GammaMedplus source consisting active length 3.5 mm with 0.6 mm diameter, and 4.52 mm physical length with 0.9 mm diameter. The distance between the distal end (or tip) of the active source pellet and the physical tip is 0.66 mm. The beam quality of the ^{192}Ir source delivers optimum treatment for the skin lesions at a superficial depth (3-5 mm). Varian vertical-type surface applicators are provided with specific diameters ranging from 10 to 45 mm. The complete set of vertical-type Varian surface applicators (Figure 1)

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consists of a total of 10 applicators; eight round (or circular) and two oval (or ovoid) shapes. Applicators are named as SA, BA, SAOV, and BAOV, respectively, for small, big, small oval-shape, and big oval-shape applicators. Small applicators comprise of 10, 15, 20 and 25 mm, whereas big applicators comprise of 30, 35, 40, and 45 mm in diameter. SAOV has 30/20 mm and BAOV has 45/25 mm orthogonal diameters of oval shape. Two fixation components known as "shielding for tubus with fixation" are also provided with this applicator set. The first one is for four small-sized round-shape applicators ranging from 10 mm to 25 mm, and the second one is for four big-sized round-shape applicators ranging from 30 mm to 45 mm, plus two oval-shape applicators [16]. The entire set of applicators was made of stainless-steel (S/S) and tungsten alloy [17], with the source guide tube positioned vertically with respect to the treatment surface within 2 mm SSD.

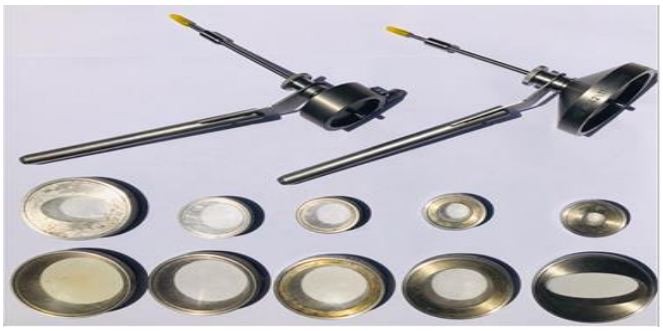

Fig. 1: Photo of a complete set of Varian vertical-type surface applicators

Applicator commissioning was previously performed by a physicist to carry out a set of measurements required. For readers, a part of commissioning, including general consideration, verification of vendor documents, and the physical integrity of the applicator prior to its first use, are briefly described here but not focused in detail. For details on commissioning, the user should refer to AAPM recommendations [18-20]. However, the report of TG-253 [21] jointly published by AAPM and GEC-ESTRO is considered for the geometrical description of the surface applicator intended for the treatment of skin cancers or lesions, commissioning, calibration, and dosimetric characteristics of these applicators. Dosimetry practice and clinical considerations & workflow for radionuclide-based conical surface applicators are also reviewed.

2.2 Physical dimensions and applicator integrity

All applicators in the set were visually inspected to observe any scratches, abrasions, or physical damage. The content of the user manual and vendor data were fully understood. The protocols and guidelines regarding the intended use, cleaning, sterilization, geometrical and dosimetric information were followed. The complete path length of the transfer tube plus the source guide tube attached to the applicator was verified to ensure 130 cm total length using the manufacturer's calibrated length gauge. This length determines the source-to-indexer distance (SID) and is essentially used in treatment planning system (TPS). A treatment setup was planned at a single dwell position, locating the source at the distal end for each and every applicator to verify that this length is settled within tolerance as well as that the source path is obstruction free. As the dose

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compromises physical geometry, i.e. the dimension and shape of the applicator, these dimensions were verified using a vernier caliper. Likewise, the geometry of the applicator insert, the shape and wall-thickness of the "shielding components" for both applicators, and the centre of the source channel were also verified. There was a nominal difference of 3 mm (communicated by Varian personal and later on verified by the end user and corrected for TPS calculations) between the lengths of the dummy path and the active source. For the evaluation of flatness and symmetry, dose distribution perpendicular to the ^{192}Ir beam axis was obtained irradiating the gafchromic films planned for a typical prescribed dose (range 4 -7 Gy) at 3 mm depth in PMMA phantom. The applicator was fully in contact with the phantom surface.

2.3 Ion chamber measurements for dose calculation

Vendor data along with after loader installation' was provided in tabulated form. The data comprises a nominal delivery time at 5 mm depth and at the surface of the applicator for dose range 3 to 5 Gy. The nominal time was associated to two distinct dwell positions (denoted as source positions, SP-3 and SP-4) moving the source 10 mm and 15 mm back from the centre of the first nominal dwell position. A very steep dose-gradient was observed when the ^{192}Ir source was positioned near the surface of the phantom, which is actually undesirable for clinical use. Therefore, the dose measurement with the source dwell position either at -5 mm or less than -10 mm, was not considered in this study. Subsequently, all the experimental readings were collected by planning the source position only at -10 mm or -15 mm back from the centre of first dwell position.

2.3.1 Measurements in PMMA phantom

Dose measurements were achieved using a Farmer-type ion chamber, TN30013-3936 (PTW Freiburg, Germany), at 5 mm depth positioned in 3 cm polystyrene slab. A PMMA slab was placed under the chamber, resulting in a total backscatter of about 6.5 cm, appropriate for ^{192}Ir measurements (Figure 2). The ion chamber used here was calibrated for ^{60}Co radiation for the optimized dose measurement.

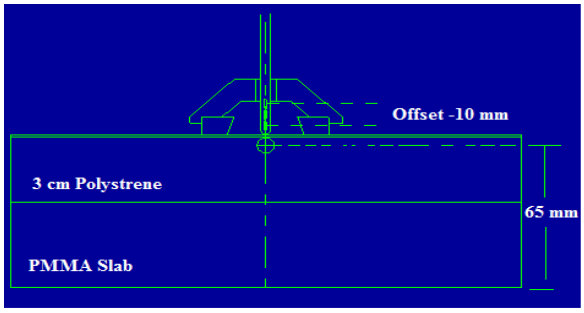

Fig. 2: Schematic of the experimental setup with a single dwell position set at -10 mm

It may not be ideal for small depth dose measurement, as in the case of the HDR ^{192}Ir source, but it was used here as the most appropriate ion chamber available at the time. Though the calibration factor for ^{192}Ir source measurements was not available for PTW

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TN30013, the calibration factor for ^{60}Co in water was used with a beam quality conversion factor (k_Q) to convert the absorbed dose from ^{60}Co to ^{192}Ir derived from published literature [15, 22-24].

Ion chamber measurements in phantom were performed without the use of a buildup cap or protection cap, thus no correction was needed for the effective point of measurement (POM). Consequently the given depth was considered to be from the mid of the chamber's active volume (23 mm, and the diameter of 7 mm). Applicator-Chamber positional accuracy was ensured using the paper templates and laser setup. The paper template was centered on the phantom surface over the chamber and aligned with the help of lasers. Any potential volume-averaging effect or stem effect was not considered. The applicator was placed on the paper template and fixed with tape. Finally, the applicator was connected to the GammaMedplus iX remote afterloading unit. The readings in solid phantom were used to calculate dose-to-water (D_w) using the equation-1:

$$D_{w,\,5mm} = M_{raw,\,PMMA} \times P_{pol,\,PMMA} \times P_{ion,\,PMMA} \times P_{el} \times P_{T,P,\,PMMA} \times N_{D,\,w}^{C0\text{-}60} \times K_Q \times P.F \quad \ldots\ldots (1)$$

Where M_{raw} is electrometer reading measured as raw value. For each applicator, $P_{pol,}$ was measured in a phantom using the high and low voltages available as 300V and 150V respectively. P_{ion} was measured by the "non-pulsed beam" formula. Air density corrections for electrometer were also considered by measuring the value $P_{T,P}$ whereas the value of P_{el} is taken as 1. As the ion-chamber was calibrated for the ^{60}Co photon beam, so K_Q was used as a correction factor for beam quality to account for the differences between the energies of the ^{192}Ir source and the ^{60}Co reference beam. The phantom factor (P.F) was used to convert ion chamber readings measured in a PMMA phantom to those measured in water. The value of P.F = 1.07 as a "solid water-to-water" phantom factor was taken from the previously but similar setup [22] as:

$$\text{Phantom Factor} = \frac{\text{Dose in Water}}{\text{Dose in PMMA Phantom}} = \frac{M_{raw,w} \cdot N_{D,W}^{C060} \cdot P_{pol,\,w} \cdot P_{ion,\,w} \cdot P_{el} \cdot P_{T,P,w}}{M_{raw,\,PMMA} \cdot N_{D,W}^{C060} \cdot P_{pol,\,PMMA} \cdot P_{ion,\,PMMA} \cdot P_{el} \cdot P_{T,P,\,PMMA}} \ldots (2)$$

Dose measurements were compared with the vendor data and the dose predicted by the TG-43 based algorithm used in BrachyVision TPS (Varian Medical Systems). The lasers and jig were used to centre the chamber. For these measurements, paper templates were centered on the top of the phantom over the ion chamber using the lasers and jig to achieve alignment. Then the applicator was placed over the template and connected to the HDR unit. Measurements were repeated 5 times and an average value was acquired for each applicator and dwell position. Isodose distribution was ensured with the best geometrical optimization in volume and distance. Isodose were generated for the assessment of dose at surface and at 5 mm depth in phantom. The results were compared with vendor data and calculated values using the TPS.

2.4 TG-43 based TPS Calculations

Due to its manufacturing design using high Z tungsten, these surface applicators are not compatible with CT/MRI, therefore they cannot be scanned using CT for treatment planning purposes. However, the availability of these applicators in the solid applicators library makes them appealing to medical physicists. Using an applicator from the library,

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the dose was calculated at 5 mm depth for all surface applicators. From the vendor's provided data, the dwell time was set so that the dose would be 3 Gy at 5 mm depth. The calculated dose was noted and the step was repeated by selecting the dwell time to compute the doses for 4 Gy and 5 Gy. Figure 3 shows an illustration of the dose line profile and the isodose curves using the BA40 applicator. The computed values resulting from TPS were compared with the measured values.

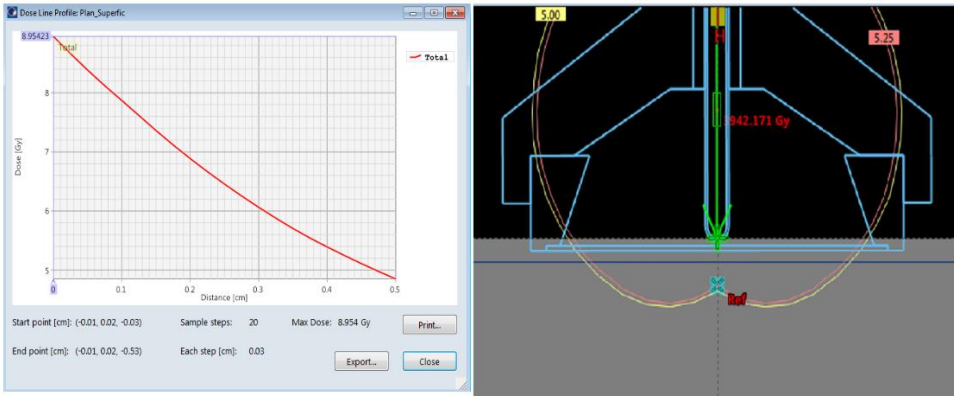

Fig. 3: Illustration of dose profile (left) and the Isodose curves (right) of BA40 surface applicator using Brachy Vision TPS

2.5 Gafchromic film measurements

Dosimetric measurements were also performed using gafchromic films. Positional accuracy was ensured as described earlier. Gafchromic films have better spatial resolution and are relatively independent of energy above 100 keV [25, 26]. For calibration, films were irradiated to a known radiation dose of upto 600 cGy with a ^{60}Co radiation beam (Theratron, Phoenix). Instructions were followed to store and handle the films as recommended in TG-55 [27]. For measurement, the films were placed at 4 mm prescription depth inside an available 30 cm^3 PMMA slab phantom. With both dwell positions, a plan was executed to irradiate the films with the dwell time set to deliver a dose of 5 Gy. All films were scanned about 24 hours post-irradiation using a flat-bed document scanner selecting the transmission mode with the reference of 75-bit RGB image. The red channel was chosen for the study because it produced a better response than the other two channels [8, 28]. Images were analyzed using ImageJ software (National Institutes of Health, USA) to obtain optical density (OD) and hence the profiles. The central axis dose along the diameter was assessed to determine the therapeutic area (in mm, the unit of diameter) which actually corresponds to dose values equal or above 90% of the prescribed dose. The profiles were also acquired using the TPS and the width of the 90% dose level was obtained.

2.6 Determination of depth dose

Depth dose measurements were performed selecting the two applicators; one big applicator (BA45) and one small applicator (SA20) following a similar experimental setup as described in section-2.3 above. Measurements were performed at a single dwell

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position located at -15 mm with 13 depth increments ranging from 5 mm to 30 mm, inserting the PMMA slabs of different thicknesses. The values obtained were normalized to dose maximum.

3. RESULTS

3.1 Physical dimensions and integrity checks

All applicators were visually inspected and found free of any physical damage or scratches. The complete path length of the surface applicator, including the source guide tube, was checked and verified by using the manufacturer's calibrated length wire. The length was found to be 130 cm, which confirms that the source path is clear and free from any obstruction along its travelling path. Using a vernier caliper providing a precision of 0.0l mm, the maximum variation noticed in physical dimension was not more than 0.5 mm. No discrepancy was detected in wall thickness or source channel centering. An HDR check-plan with complete dosimetry setup was tested prior to any dose measurement and was accomplished successfully with full integrity.

3.2 Ion chamber measurements for dose calculations

Table-1 shows that the output dose measurements obtained at 5 mm depth. The measured values were in good agreement with vendor data and TPS values, with a percent (%) difference not exceeding 10% except using SA10, the smallest applicator. When the source was positioned at -10 mm, the measured values showed reduced agreement with vendor data and TPS calculations. The measured values showed a difference ~13% and ~6% respectively, for vendor data and TPS calculations. When the source was positioned at -15 mm, the agreement was ~9% and ~5% respectively with vendor data and TPS calculations. In both cases, SA10 was observed with poor agreement, showing the highest percentage difference of up to 14% with the vendor and 5% with TPS calculations.

Table 1: Percent difference between measured dose Vs vendor data and TPS calculations

Applicator	% diff. Vendor -10 mm	% diff. TPS -10 mm	% diff. Vendor -15 mm	% diff. TPS -15 mm
SA10	10.0	1.9	14.0	5.0
SA15	3.9	4.7	4.5	4.8
SA20	3.7	2.9	4.3	4.5
SA25	2.0	4.2	4.7	3.2
BA30	4.7	2.2	3.9	2.3
BA35	13.1	6.0	4.5	1.7
BA40	4.7	1.5	3.9	1.6
BA45	4.1	1.3	3.5	0.9
SAOV	4.7	1.3	9.0	5.0
BAOV	5.0	2.7	4.9	2.8

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3.3 Gafchromic film measurements

The profiles at 4 mm prescription depth generated from films showed a symmetric dose fall according to the shape and size of the applicators, ensuring that the ^{192}Ir source is dosimetrically at the centre of the applicator. Table-2 shows the 90% dose width for the values obtained from film measurements, vendor data and TPS calculations. For dwell position located at -15 mm, the agreement of film measurements was within ~2 mm and ~3 mm, respectively, with vendor data and TPS calculations. For the dwell position located at -10 mm, the agreement was within ~2 mm with both the vendor data and TPS calculations. It was observed that film measurements are dependent on spatial resolution, as the maximum resolution for the dose calculation grid in BrachyVision TPS was 0.5 mm.

Uncertainty of measurements

$^{C0\text{-}60}N_{D,\,w}$ factor for PTW-30013 was calibrated by SSDL with uncertainty of 0.54%. The uncertainty in the product of correction factors was obtained as 0.21% from certificate. The uncertainty estimate on dose parameters adds to the combined uncertainty (1 s.d) on the dose measurements as shown in Table-3.

Table 2: Therapeutic area (in mm) or width of 90% dose level obtained from film measurements, vendor data and TPS calculations

Applicator	Dwell Position -15 mm			Dwell Position -10 mm		
	Film Meas.	Vendor	TPS	Film Meas.	Vendor	TPS
SA10	6.4 ± 0.2	5.0	7.6	5.0 ± 0.6	6.0	6.4
SA15	7.3 ± 0.2	7.0	8.9	9.6 ± 0.1	10.0	11.4
SA20	9.4 ± 0.5	10.0	12.1	15.2 ± 0.1	14.0	15.6
SA25	10.8 ± 0.7	10.0	12.9	16.2 ± 0.2	17.0	18.1
BA30	21.4 ± 0.4	23.0	24.1	19.4 ± 0.5	21.0	21.2
BA35	24.3 ± 0.2	26.0	27.3	20.2 ± 0.3	22.0	22.2
BA40	27.9 ± 0.1	29.0	28.1	22.5 ± 0.1	23.0	24.1
BA45	29.4 ± 0.3	28.0	30.6	25.8 ± 0.4	24.0	25.5
SAOV-Long axis	18.4 ± 0.3	20.0	21.0	16.6 ± 0.7	18.0	18.4
SAOV-Short axis	16.3 ± 0.6	17.0	18.0	18.8 ± 0.5	17.0	19.7
BAOV-Long axis	23.0 ± 0.4	25.0	24.6	23.0 ± 0.2	21.0	24.2
BAOV-Short axis	22.1 ± 0.7	23.0	23.0	23.0 ± 0.5	21.0	22.2

Table 3: Uncertainty analysis for PTW-TN30013 ion chamber dose measurements

Quantity	Type A (%)	Type B (%)
$^{Co\text{-}60}N_{D,w}$	---	0.54
$P_{ion}.\ P_{pol}.\ P_{elec}.\ P_{T,P}$	---	0.21
K_Q	---	1.10
Phantom factor (p.f)	0.06	---
Reproducibility of measurements (n=5)	0.29	---
Chamber positioning accuracy	---	0.28
Combined uncertainty (1 s.d)	0.62	

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3.4 Determination of percent depth dose (PDD)

Figure 4 shows PDD plots normalized to dose maximum for two dwell positions located at -15 mm and -10 mm. The dose falloff was observed at -10 mm source location for a depth ranging from 7 mm to 20 mm. The values of depth-dose measurements at a single dwell position of -15 mm are plotted in Figure 5(a) for BA40 and in Figure 5(b) for SA20. The data was normalized to dose maximum. The profiles reflect the expected steep dose-gradients in superficial therapy. In terms of trends, both curves exhibit nearly identical behavior. The profile in Figure 5(c) reveals that all applicators, when used at the same dwell position, show identical curves, which concludes that the applicator size and shape do not influence the depth dose. Figure 5(d) describes a comparison of the measured PDD plot with the plot generated from vendor data and TPS calculations. Measured values were slightly lower than vendor data and TPS values but still show the best agreement. For a single applicator BA40, the depth-dose measurements were also taken at a dwell position of -10 mm.

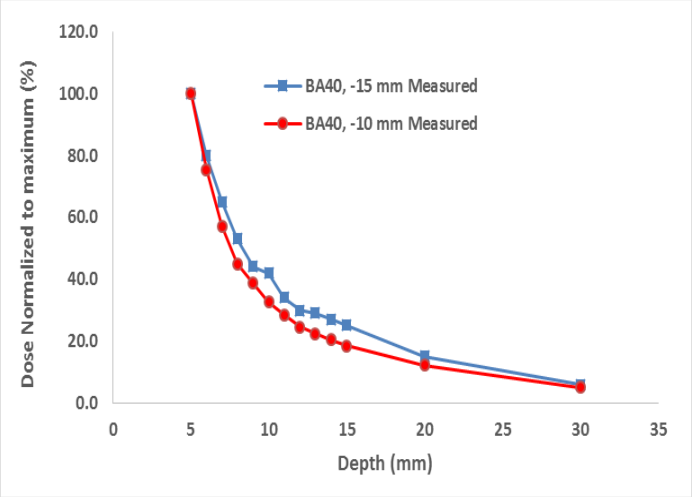

Fig. 4: PDD plots of BA40 with source located at two dwell positions, -15 mm and -10 mm

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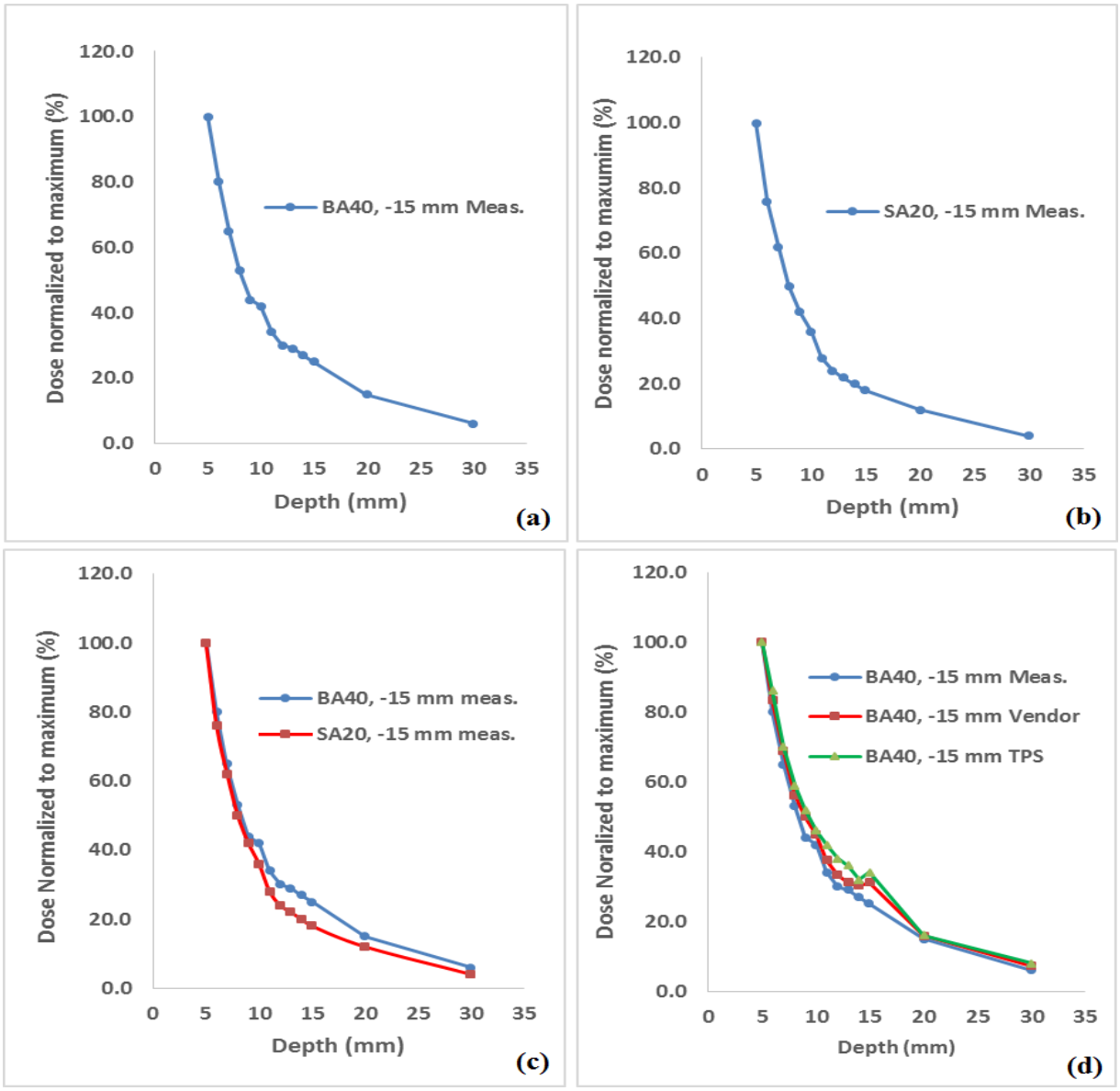

Fig. 5: PDD Plots at -15 mm (a). Depth-dose measurements for BA40 applicator (b). Depth-dose measurements for SA20 (b). Comparison of two applicators; BA40 and SA20 at same dwell positon (d). Comparison of measured depth-dose plot to Vendor data and to TPS

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4. DISCUSSION

This study was aimed to develop an independent, useful methodology for the verification of dose output validating the vertical-type surface applicators used in brachytherapy clinical practice. Literature shows a small number of publications, which may be due to limited clinics with such kinds of standard dosimetry tools available to them and presenting a multifarious methodological approach for vertically oriented surface applicators. While most medical centres still have issues with non-availability of calibration services' provided by local SSDLs and traceable to PSDL or NIST, for dosimetry tools such as Farmer-type ion chambers or even well-type chambers for ^{192}Ir source measurements.

Moreover, calibration factors for the available radiation detectors are limited to being used only in the measurement of a specific beam quality and may not be ideal for the beam quality of interest. For instance, a typical Farmer ion chambers are calibrated only for ^{60}Co beam energy and have no standards to calibrate it for ^{192}Ir beam quality. Thus, it is least accurate for ^{192}Ir brachytherapy source at short distance due to its large geometric dimensions. The current study will be used as a guide for medical centres using HDR surface brachytherapy to manage and establish dosimetric QA with limited dosimetry setup.

In the current study, the dose from the exit window of a set of Varian vertical-type surface applicators was measured with an ion chamber positioned in a solid phantom at 5 mm depth. Measured values are then compared with vendor data and planned doses at two different dwell positions. These results are comparable not only to vendor data but also with literature [13]. This study has validated its dosimetric performance in clinical practice and may serve as a base line for medical centres seeking knowledge about ^{192}Ir measurements with limited dosimetry tools.

HDR surface applicator SA10 showed reduced agreement. The possible reason may be its small diameter, which may cause comparatively more alignment errors in experimental setup than other applicators with larger diameters. The 90% dose level indorsing the skin lesion receiving equal or above 90% of the prescribed dose' has great significance for the optimized dose delivery to the target region. There may be many issues that affect the accuracy and precision of obtaining reliable optical density values, for instance, scanning orientation and scanner uniformity. So, it gives a higher percent difference in measurements.

5. CONCLUSION

The current research work demonstrates a simple, easy and an independent way to measure the dose to skin tumors using vertical-type surface applicators intended with ^{192}Ir source. An independent verification method validate good agreement between reference and measured values and give confidence that superficial treatment are being delivered accurately. Moreover, a quality assurance program may be developed to check the applicator's integrity and to verify the output dose for the treatment of skin lesions,

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ultimately improving the quality of work and patient care. Furthermore, it is suggested that the smallest applicator, SA10, may be avoided for clinical purposes, otherwise it must be used with great setup accuracy.

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