Review paper

UK & Ireland Prostate Brachytherapy Practice Survey 2014-2016

Gemma Corey, MRCP FRCR[1], A.B. Mohamed Yoosuf, MSc[2], Geraldine Workman, MSc[2], Monica Byrne, MSc[2], Darren M. Mitchell, MD[1], Suneil Jain, MD, PhD[1,3]

[1]Department of Clinical Oncology, Northern Ireland Cancer Centre, Belfast City Hospital, [2]Department of Radiotherapy Medical Physics, Northern Ireland Cancer Centre, Belfast City Hospital, [3]Queens University, Belfast, Antrim, Northern Ireland, UK

Abstract

Purpose: To document the current prostate brachytherapy practice across the UK and Ireland and compare with previously published audit results.

Material and methods: Participants from 25 centers attending the annual UK & Ireland Prostate Brachytherapy Conference were invited to complete an online survey. Sixty-three questions assessed the center's experience and staffing, clinician's experience, clinical selection criteria and scheduling, number of cases per modality in the preceding three years, low-dose-rate (LDR) pre- and post-implant technique and high-dose-rate (HDR) implant technique. Responses were collated, and descriptive statistical analysis performed.

Results: Eighteen (72%) centers responded with 17 performing LDR only, 1 performing HDR only, and 6 performing both LDR and HDR. Seventy-one percent of centers have > 10 years of LDR brachytherapy experience, whereas 71% centers that perform HDR brachytherapy have > 5 years of experience. Thirteen centers have 2 or more clinicians performing brachytherapy with 61% of lead consultants performing > 25 cases (LDR + HDR) in 2016. The number of implants (range), that includes LDR and HDR, performed by individual practitioners in 2016 was > 50 by 21%, 25-50 by 38%, and < 25 by 41%. Eight centers reported a decline in LDR monotherapy case numbers in 2016. Number of center's performing HDR brachytherapy increased in last five years. Relative uniformity in patient selection is noted, and LDR pre- and post-implant dosimetry adheres to published quality guidelines, with an average post-implant D_{90} of > 145 Gy in 69% of centers in 2014 and 2015 compared to 63% in 2016. The median CT/US volume ratios were > 0.9 ≤ 1.0 (n = 4), > 1.0 ≤ 1.1 (n = 7), and > 1.1 (n = 2).

Conclusion: There is considerable prostate brachytherapy experience in the UK and Ireland. An apparent fall in LDR case numbers is noted. Maintenance of case numbers and ongoing compliance with published quality guidelines is important to sustain high quality outcomes.

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Key words: LDR prostate brachytherapy, HDR prostate brachytherapy, UK & Ireland.

Purpose

Low-dose-rate (LDR) permanent seed and high-dose-rate (HDR) temporary source brachytherapy are well recognized and effective treatment options for selected patients with localized prostate cancer of any risk group [1,2,3,4,5,6]. Brachytherapy as monotherapy or combination with external beam radiotherapy (EBRT) have demonstrated excellent results and improved biochemical outcomes when compared with EBRT monotherapy alone [7,8,9]. Ongoing developments with multi-modality imaging (US/CT/MRI) and adaptive treatment planning allows dose distributions to be calculated and updated in real time based on the clinical requirements [10]. Despite this, the use of brachytherapy across the world has been in decline over the last decade possibly due to broadening surgical practice, improved convenience of hypo-fractionated EBRT, and fewer residents in brachytherapy training programs [1,11,12].

The aim of this survey is to document the current prostate brachytherapy practice across UK and Ireland as compared to the previous Royal College of Radiologist's (RCR) Audit in 2012, where possible [13]. Further, we wished to assess the application of standards as set out in RCR guidance and other international publications on quality assurance [2,3,4,5,6].

Material and methods

Centers attending the UK & Ireland Prostate Brachytherapy Conference (Belfast, 2017) were invited to complete (one response per department) an online survey (Survey Monkey™).

Address for correspondence: Ahamed Badusha Mohamed Yoosuf, MSc, MIPEM, Clinical Scientist, Department of Radiotherapy Medical Physics, Northern Ireland Cancer Centre, Belfast City Hospital, 51 Lisburn Road, Belfast BT9 7AB, United Kingdom, e-mail: ahamed.badusha@belfasttrust.hscni.net

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Sixty-three questions were grouped into six themed sections as follows:

1. Centre's experience and staffing.
2. Consultant experience, clinical selection criteria and scheduling: number of implants per practicing consultant (banded as < 25, 25-50, and > 50), clinical selection demographics, treatment scheduling, and follow-up arrangements.
3. Number of cases treated in the preceding 3 years (banded into 0-15, 15-25, 25-50, and > 50).
4. LDR pre-implant technique: imaging/contouring, implant details, source strength, average number of seeds/needles, treatment planning (TP) objectives, and constraints.
5. LDR post-implant technique: imaging/contouring, prostate D_{90}, room monitoring, and seed loss.
6. HDR implant technique: imaging/contouring, implant type, image registration, prescription dose, TP objectives, achieved dosimetry ($V_{100\%}$), and *in-vivo* dosimetry.

Responses were collated, and descriptive statistical analysis performed.

Results

Centre's experience and staffing

Eighteen (72%) of 25 invited centers responded within the timeframe. Seventeen centers perform LDR permanent seed implantation compared to 15 in 2012, and 7 canters perform HDR prostate implant compared to 3 in 2012 [13]. Six centers perform both LDR and HDR implants as opposed to 7 in 2012, and 1 center performs HDR implantation only. Twelve (of 17) centers performing LDR brachytherapy have more than 10 years' experience, and 5 (of 7) centers carrying out HDR implantation have more than 5 years' experience. One center has less than 1-year HDR brachytherapy experience, whilst 2 centers have over 15 years' experience.

The RCR's quality assurance (QA) practice guidelines for LDR permanent seed brachytherapy recommend a minimum of 2 radiation oncologists and 2 medical physics experts (MPE) on each brachytherapy team to 'ensure service resilience' [6]. Table 1 shows the current reported staffing levels. Thirteen (76%) centers have 2 or more implanting consultants, and 15 (88%) centers have 2 or more medical physics experts as opposed to 25 centers in 2012 that had 2 or more clinical oncologists and MPEs [13].

Clinical and patient selection criteria

Number of implants per consultant (2016)

RCR guidelines recommend a minimum workload of 25 cases (LDR + HDR) per clinical oncologist (CO) per year [6]. As shown in Table 2, 39% of centers reported that their leading consultants performed < 25 cases in the year 2016. Similarly, 38% and 50% centers reported that their 2nd and 3rd consultants have performed < 25 cases in 2016, respectively.

Treatment scheduling

Twelve centers perform LDR combination therapy with 7 centers performing EBRT pre- and 5 performing EBRT post-brachytherapy. Of the 7 centers performing HDR combination therapy, 5 centers perform the HDR implant pre- and 2 centers carry out the HDR implant post-EBRT.

Table 1. Brachytherapy staff numbers in UK and Ireland 2017

Staff member	No of respondents (total *n* = 18)	Number of staff per center (whole time equivalent)			
		1	2	3	> 3
Implanting consultants	18	5	7	4	2
Medical physics expert	18	3	9	5	1
Clinical scientist	16	0	5	6	5
Therapy radiographers	13	2	2	5	4
Physics trainees	15	8	3	2	2
Clinical trainees	6	4	1	0	1

UK – United Kingdom

Table 2. Number of implants (low- + high-dose-rate) performed by each consultant (2016)

Staff	No of respondents (total *n* = 18)	Number of implants performed in the year 2016		
		< 25	> 25-50	> 50
Consultant 1	18	7	7	4
Consultant 2	13	5	5	3
Consultant 3	6	3	2	1

LDR – low-dose-rate, HDR – high-dose-rate

Patient selection criteria for low-dose-rate prostate monotherapy

The responses from centers on patient selection and criteria for LDR prostate monotherapy based on various factors are reflected in Table 3. Hormonal manipulation along with LDR treatments was used in 56% of centers in selected cases for either cyto-reduction prior to implant or as an adjuvant therapy for tumor management. Current data is compared to previous published surveys.

Clinical follow-up

Clinical follow-up post-therapy is performed by oncology in 9 centers, shared care in 6 centers, and 1 center offering radiographer led follow-up alone.

Number of cases treated in 2014-2016

The number of cases treated during 2014-2016 is presented in Table 4, collected using banded groups: < 15 cases,

Table 3. Clinical selection criteria for low-dose-rate prostate monotherapy – comparison of current survey with previous American Brachytherapy Society Surveys (1998 and 2012)

Criteria	Prestidge *et al.* [14]	Buyyounouski *et al.* [15]	Current study
	Respondents (%)	Respondents (%)	Respondents (%)
Gleason score; number of respondents	(*n* = 35)	(*n* = 63)	(*n* = 17)
6	12 (37)	17 (27)	–
7	12 (37)	40 (63)	15 (88)
8	5 (14)	5 (8)	1 (6)
9	6 (17)	1 (2)	1 (6)
Maximum T stage; number of respondents	(*n* = 35)	(*n* = 60)	(*n* = 17)
T1	2 (6)	5 (8)	–
T2	31 (88)	53 (89)	15 (88)
T3A	2 (6)	2 (3)	2 (12)
Maximum prostate size in cc; number of respondents	(*n* = 35)	(*n* = 59)	(*n* = 15)
30/40	3 (9)/5 (14)	–/4 (7)	–
50	11 (31)	6 (10)	4 (27)
60	13 (37)	31 (53)	7 (46)
> 60	3 (9)	18 (30)	4 (27)
Maximum PSA	(*n* = 35)	(*n* = 59)	(*n* = 17)
< 10	11 (31)	23 (39)	2 (12)
< 15	10 (29)	20 (34)	8 (47)
< 20	8 (23)	15 (25)	6 (35)
> 20	5 (14)	1 (2)	1 (6)
Previous TURP	(*n* = 35)	(*n* = 63)	(*n* = 15)
Not a contradiction/not considered	12 (34)	8 (12)	5 (33)
Relative contradiction	19 (54)	52 (83)	6 (40)
Absolute contradiction	4 (11)	3 (5)	4 (27)
Hormonal manipulation	(*n* = 35)	(*n* = 0)	(*n* = 16)
Yes	94%	–	9 (56)
No		–	7 (44)

PSA – prostate specific antigen, TURP – transurethral resection of the prostate, cc – cubic centimeter

15-35 cases, 35-50 cases, 50-75 cases, and > 75 cases per year.

Low-dose-rate pre-implant technique

Implant type and prescription dose

The majority (14 of 17 centers) perform LDR brachytherapy as a 'real-time' implant, and 3 centers perform a 'two-step procedure'. All 17 centers use ^{125}I seeds, and 1 center also uses ^{103}Pd and ^{131}Cs. A prescription dose of 145 Gy for LDR monotherapy is used in 13 (76%) centers compared with 95% in the 2012 audit [13]. Four centers use a prescription dose of 160 Gy. For LDR combination with EBRT, the prescription dose was 110 Gy in 100% of centers in 2012. However, in 2014-2016 it is reported as: in 8 centers – 110 Gy, 2 centers – 106 Gy, 2 centers – 107 Gy, 1 center – 115 Gy, and 1 center did not specify.

Imaging and contouring

The most common imaging modality is ultrasound (USS), used by 65% of centers for the pre-treatment vol-

Table 4. Number of cases treated between 2014 and 2016

Techniques	Respondents (total *n* = 18)	No of cases treated				
		< 15	> 15-35	> 35-50	> 50-75	> 75
LDR monotherapy						
2014	17	1	6	2	6	2
2015	17	1	6	3	4	3
2016	17	5	2	4	5	1
LDR boost + EBRT						
2014	7	–	6	–	1	–
2015	8	–	6	–	2	–
2016	8	–	8	–	–	–
LDR focal						
2014	1	1	–	–	–	–
2015	1	1	–	–	–	–
2016	1	1	–	–	–	–
LDR salvage						
2014	2	2	–	–	–	–
2015	4	4	–	–	–	–
2016	5	5	–	–	–	–
HDR boost						
2014	5	1	–	–	–	4
2015	5	1	–	–	–	4
2016	6	2	–	–	2	2
HDR mono						
2014	4	3	–	1	–	–
2015	5	2	2	–	1	–
2016	6	4	1	–	1	–
HDR salvage						
2014	1	1	–	–	–	–
2015	3	3	–	–	–	–
2016	3	3	–	–	–	–

LDR – low-dose-rate, HDR – high-dose-rate, EBRT – external beam radiation therapy

Table 5. Planning objectives used by all centers

Dosimetric objectives and constraints	Objective (number of respondents)	Number of respondents
Prostate		
$V_{100\%}$ (n = 17)	> 99.8%	1
	> 99.5%	1
	> 99%	5
	> 98%	2
	> 95%	8
CTV		
$V_{100\%}$ (n = 9)	> 95%	7
	Don't grow CTV	1
	CTV = prostate	1
Prostate		
$V_{150\%}$ (n = 15)	< 70%	2
	< 65%	2
	< 60%	2
	> 55-65%	1
	55-60%	1
	< 55%	1
	< 50%	1
	40-65%	1
CTV		
$V_{150\%}$ (n = 8)	< 70%	1
	< 65%	1
	< 50%	4
	Don't grow CTV	1
	CTV = Prostate	1
Urethra		
$D_{30\%}$ (n = 11)	< 130%	5
	< 150%	3
	< 181 Gy	2
	< 240 Gy	1
$D_{10\%}$ (n = 8)	< 150%	7
	< 165%	1
$V_{150\%}$ (n = 1)	= 0 cc	1
$V_{140\%}$ (n = 1)	< 5% of the volume	1
Rectum		
$V_{100\%}$ (n = 6)	< 5%	2
	< 0.4 cc	1
	< 0.9 cc	1
	< 1 cc	1
	< 1.3 cc	1
D_{2cc} (n = 10)	< 145 Gy	10
$D_{0.1cc}$ (n = 3)	< 200 Gy	3
$V_{69\%}$ (n = 1)	< 2.6 cc	1
$V_{91\%}$ (n = 1)	< 1 cc	1

CTV – clinical target volume, $V_{x\%}$ – volume receiving x% of the prescribed dose, D_{xcc} – dose received by x cc of the volume, $D_{x\%}$ – dose received by x% of the volume, Gy – Gray, cc – cubic centimeter

ume study. Multiple modality imaging is used in 4 centers and 1 center uses MRI. Pre-treatment contouring is performed by the oncologists (38%), radiologists (13%), radiographers (13%), urologists (19%), and others (19%), which includes physicists. Image registration/fusion is used in 3 centers.

Treatment planning, seed placement, and source strength

Treatment planning (TP) is carried out by a physicist or dosimetrist in all the centers. During the implant, the ultrasound is operated by the oncologist (n = 9) or urologist (n = 9), radiologist (n = 5) or physicist (n = 1).

The majority of centers (n = 10) use stranded seed placement, 1 center uses a variation of all 4 placements including stranded, preloaded, loose, and Mick applicators. Seven centers use loose seeds for calibration, 5 use strands, and 1 center uses both. Most centers use a reference air kerma rate (RAKR) of 0.5-0.6 U (n = 12) or 0.4-0.5 U (n = 11), and 1 center uses a RAKR of > 0.7 U.

The mean number of needles used are 23 (± 5) and mean number of seeds are 72 (± 9) per LDR monotherapy implant, although this is RAKR dependent. The average number of needles and seeds per unit volume (cc) is 0.85 (± 0.5) and 1.9 (± 0.5), respectively.

Planning objectives and independent dose calculation verification

The objective for prostate $V_{100\%}$ is ≥ 99% at 7 centers, > 98% at 2, and > 95% at 8 centers. Seven centers require a clinical target volume (CTV) $V_{100\%}$ of > 95%. Fifteen centers report $V_{150\%}$ to the prostate and 8 centers report $V_{150\%}$ to a CTV. $D_{30\%}$ to the urethra is reported by 11 centers and the majority aim for < 130% of prescribed dose. $D_{10\%}$ is reported by 8 centers, with the majority aiming for < 150%. The majority of centers (n = 11) report a limit for D_{2cc} rectum as < 145 Gy. A variety of constraints for prostate, CTV, urethra, and rectum were applied during treatment planning as shown in Table 5.

Post-implant dosimetry

Post-implant CT scans are routinely performed in all centers compared with 77% in 2012 [13]. Ninety-four percent (n = 16) perform the scan 4-6 weeks later, and one center on day 0/day 1. Similar to the pre-implant contouring, the oncologist performs the majority (n = 10) of the post-implant contouring followed by radiographers (n = 4), and others such as the radiologist, physicist, and dosimetrist (n = 3). Thirteen centers perform routine calculation of the CT/ultrasound volume. The median CT/US volume ratios were > 0.9 ≤ 1.0 (n = 4), > 1.0 ≤ 1.1 (n = 7), and > 1.1 (n = 2). Three centers routinely perform image registration or fusion in post-implant dosimetry, and sector analysis is performed by 4 centers.

The average prostate D_{90} (Gy) achieved over the period 2014-2016 is displayed in Table 6. Sixty-nine percent of the centers reported average D_{90} > 145 Gy in the years 2014 and 2015, whereas 63% of the centers achieved > 145 Gy in 2016.

Table 6. Post-implant average D_{90} for the three-year period (2014-2016)

Year	No of respondents	Post-implant D_{90}			
		< 145 Gy	> 145-155 Gy	> 155-170 Gy	> 170 Gy
2014	16	5 (31%)	3 (19%)	6 (37%)	2 (13%)
2015	16	5 (31%)	3 (19%)	7 (44%)	1 (6%)
2016	16	6 (37%)	2 (13%)	4 (25%)	4 (25%)

D_{90} – dose to 90% of the prostate volume, Gy – Gray

Post-procedure radiation protection room monitoring is usually performed by a nurse or physicist. Average seed loss, whereby seeds implanted were not seen on post-implant dosimetry, was < 3 per year in the majority of centers, 2 centers had seed loss > 3, but < 10 seeds per year based on number of seeds implanted versus number identified on the post-implant CT.

High-dose-rate brachytherapy technique

Of the 6 centers performing HDR monotherapy, 5 centers prescribe 19 Gy to 100% isodose volume and ensure that 95% of planning target volume (PTV) is encompassed by the 100% isodose, whereas 1 center prescribes 19 Gy to 90% of prostate volume. The definition of CTV was not acquired in this survey, although the GEC/ESTRO recommendations define CTV as the prostate capsule plus any macroscopic extracapsular disease or seminal vesicle involvement expanded by 3 mm, constrained by the anterior rectal wall and bladder base [5]. Seven centers report HDR boost doses of 15 Gy; 5 centers prescribing to 100% isodose volume and 2 centers to 90% prostate volume. Salvage therapy is performed by 4 centers, with 2 centers prescribing 15 Gy to 100% isodose volume, and the others prescribing 19 Gy to 100% isodose volume or 90% of prostate volume.

Although none of the centers performed focal therapy during the 3-year period, 1 center suggested that the prescription dose would utilize a focal boost of 21 Gy to the dominant lesion and 15 Gy to the non-dominant prostatic PTV (although definition of same not provided). Details of cases numbers are detailed in Table 4.

In all but 1 center, the oncologist performs the pretreatment contouring, with the other done by the radiologist. Ultrasound guidance is used in all centers for implants and routine QA is performed in all centers; 5 centers use metal needles and 2 use plastic needles, and most centers report an average of 15-20 needles per implant. Three centers utilize image registration (US and MRI).

The average percentage of the target volume receiving 100% of the dose ($V_{100\%}$) is 95-98% in 4 centers, > 95% in 1 center, and 98-100% in 2 centers. Independent dose calculation verification is carried out in all centers. One center performs in vivo dosimetry measurements using MOSFET detectors.

Comparison with 2012 RCR Prostate Brachytherapy Audit

Table 7 includes the current standards, where comparable to the standards achieved in the 2012 Audit [13].

Discussion and conclusion

Whilst the current survey had fewer responses than the RCR 2012 audit, we believe it is an accurate represen-

Table 7. 2014-2016 reported standards compared to the 2012 RCR Survey Standards

	RCR standard recommendations	RCR target	Standard achieved (2012) respondents %	Standard reported 2014-2016 respondents %
1	Each department should carry out at least 25 cases/year [15]	100%	100%	71% centers treated > 15 cases of LDR in 2016
2	Each CO should carry out at least 5 cases/year [15]	100%	95%	Not recorded in current survey but 59% CO carry out at least 25 cases/year
3	Dose prescribed for LDR should be 145 Gy for monotherapy and 110 Gy for boosts [5,6]	100%	95% – monotherapy 100% – boost	76% – 145 Gy monotherapy 24% – 160 Gy monotherapy 64% – 110 Gy as boost
4	PID should be carried out [6,16,17]	95%	95% 77% routinely	100%
5	PID should be carried out at day 30 [17]	90%	32%	94% – 4-6 weeks 6% – day 0/1
6	Dose to OAR should be assessed [16,17]	90%	95% – 1+ organ 32% – 2+ organs	88% reported tolerances for 2 organs

RCR – Royal College of Radiologists, CO – clinical oncologist, LDR – low-dose-rate, PID – post-implant dosimetry, OAR – organs at risk, Gy – Gray

tation of prostate brachytherapy practice in the UK and Ireland, documenting the evolution in techniques and case numbers over the preceding 3 years. There is a clear focus on maintaining high quality implants, as evidenced by the reported D_{90}'s and the universal use of the 3 key RCR QA markers in LDR of D_{90}, CT/US volume ratio, and V_{100} across responding centers.

We note a number of centers reporting a reduction in LDR cases from 2014 to 2016 either as monotherapy or as combination therapy [1,2,3,4,5,6,7,8,9,10,13,18,19]. ASCENDE RT showed that men treated with LDR boost were twice as likely to be biochemically failure-free when compared to EBRT alone, was only presented in February 2015 at GU ASCO, and thus may not have impacted practice immediately [20]. However, it is also possible that the companion paper on toxicity could have negated the impact of this important study [21]. The continuous improvement in planning technology and review of expansion margins may help to reduce the potential of long-term urinary toxicity in combination cases, whilst hoping to maintain the biochemical benefit over EBRT alone.

The number of LDR boost treatments overall is modest. Robotic radical prostatectomies, improving convenience of hypo-fractionated EBRT for low- to intermediate-risk disease, following the CHHiP trial publication, and research interests in stereotactic radiotherapy are competing treatment options that may have impacted on referral practice [22,23,24].

HDR brachytherapy boost numbers appear to be increasing with more centers offering this modality in the last 5 years. Whilst the procedure time is longer, the radiobiological advantages, improved USS-based planning software, reduced reliance on operator skill, and potential consumable cost saving may have contributed to the limited impact of ASCENDE RT on the number of LDR boosts being performed. This cohort of high tier intermediate and high-risk cases are perhaps now directed toward HDR combined with EBRT with its own supporting evidence base [25,26].

The number of implants performed by individual consultants is noteworthy. Firstly, based on the RCR guidance, consultants are encouraged to perform at least 25 cases per year, our survey shows that 41% of implanting consultants in 2016 carried out less than this number. This may be due to the apparent fall in LDR cases reported by some centers in our survey or to an increasing number of implanting consultants individually performing fewer cases. The 2012 Audit reported that 100% of centers performed > 25 cases per year, although specific numbers per consultant was not documented but 95% of consultants performed at least 5 implants per year [12]. Secondly, the RCR guidelines suggest that in order to mentor a trainee in brachytherapy, the mentor should be performing > 100 implants over the preceding 3-year period. Our survey therefore suggests that the potential mentor cohort based on this guidance is modest. Trainees may therefore have limited exposure to brachytherapy, as has been reported in the US [26]. Reduced trainee experience and exposure to prostate brachytherapy could shrink the collegiate knowledge of patient selection and the procedure, leading to a reduced referral rate.

This survey was limited by the lower number of responses received from institutions (n = 18) than the previous 2012 RCR audit (n = 29). It is unclear if this represents failure to respond or if there has been a true reduction in the number of centers offering brachytherapy and consolidating their cases to higher volume centers. This could be answered by repeating the RCR audit using the same methodology as in 2012 and adapting our survey questionnaire. We recognize that the information gained in this survey would have been enhanced by asking for the absolute number of cases per year, their referral sources, and the specific prescription points used for the dosimetric variables, including target volume definitions and expansion margins used.

Pleasingly, our survey shows that all brachytherapy teams are continually reviewing and assessing implant quality by performing post-implant dosimetry in 100% of cases, and as an adaptive process may identify and adjust parameters for their center that maintain and improve dosimetric quality, biochemical, and toxicity outcomes.

For men with localized prostate cancer, LDR/HDR monotherapy or EBRT combined with LDR/HDR boost provides excellent biochemical outcomes [1], and several studies have reported superior outcomes, reduced toxicities, and excellent quality of life at a low-cost from either form of brachytherapy when compared to other treatments. Prostate brachytherapy offers suitable men an outstanding opportunity to achieve a high-dose, precisely targeted, and convenient treatment with excellent biochemical outcomes [2,3,7,27,28,29,30,31,32,33,34,35,36].

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Disclosure

The authors report no conflict of interest.

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