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EVALUATING THE RELIABILITY OF ORTHOGONAL IMAGE BASED PLANNING IN INTERSTITIAL BRACHYTHERAPY OF TONGUE USING CONE-BEAM CT

Oncology

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ABSTRACT

Aim: To compare the target dose coverage, dose homogeneity and dose received by the mandible in orthogonal image based interstitial brachytherapy using Cone beam CT.

Materials and methods : Six HDR interstitial implantations done at our institute were taken in this study. Both conventional orthogonal and CBCT images were acquired after implantation. Orthogonal image based planning was done in PLATO treatment planning system. CBCT images were imported to Oncentra treatment planning system. Target volumes; organ at risk (mandible) were contoured. Catheters, source positions and dwell times based on conventional orthogonal images were superposed and co registered to the contoured CBCT images.Dosimetric outcomes were evaluated qualitatively by visualizing isodose distribution on CT images and quantitatively using the dose volume parameters, which includes coverage relative dose homogeneity index (HI), overdose volume index (OI) , conformal index (COIN), dose nonuniformity ratio (DNR) and natural dose ratio (NDR).Mandible 5cc volume dose was also used as a parameter in evaluating the plans.

Results: Out of 6 patients with a median follow up of 16-18 months, all of them developed mucositis post treatment lasted for 6-8 wks. One patient had local reccurence and underwent salvage glossectomy. Another patient had ipsilateral level II nodal recurrence which was FNAC positive and underwent ipsilateral radical neck dissection. Remaining 4 patients had prophylactic superior homohyoid neck dissection (SOHND). In regard to dosimetric indices good target coverage by the prescription dose was achieved with geometric optimization (mean V100 of 82.52% (14 SD), with 150% and 200% of the target volume receiving 36.7% and 17.99% of prescription dose, respectively. Conformity and homogeneity were good with mean COIN = 0.005 and mean HI = 0.48 providing better conformity and homogeneity to the target.

Conclusion: Even though target coverage was adequate in orthogonal image based planning, the CBCT verification resulted in modification of dwell time and source positions to avoid excess dose to mandible in certain plans. We conclude that conventional orthogonal image based planning is equivalent to CT based planning in terms of target coverage but CBCT based planning can accurately predict the dose to the organs at risk (mandible).

KEYWORDS:

Interstitial brachytherapy, Cone beam CT

Introduction:

Oral cancer is one of the most commonest carcinoma in India. Squamous cell carcinoma comprises of among all. 90% of oral cancer can be attributed to specific etological agents it is known that single greatest factor for oral cancer is usage of tobacco. Among oral cavity , ca tongue comprises .Potential treatment options for management of carcinoma of tongue includes primary radiotherapy and surgery.surgical management requires resection of tongue and rehabilitation later. Whereas by using brachytherapy the shape and function of tongue can be preserved.early lesions (T1) can be treated with interstitial brachytherapy alone and has a high local control when compared to surgery

Materials and Methods:

The key to correct and effective use of brachytherapy liein pre assessment and investigation which include detailed history, full physical examination including neck, appropriate investigation and multi disciplinary consultation.

Patients data and therapy:

In our study , we analysed 6 patients with T1 tongue carcinoma according to TNM classification who were treated with sole modality of radiation therapy between Jan – Dec 2011 in our department. All were treated with a total dose of 45-50 Gy in 10 # over 5 days with minimal interfractional interval of 6-8 hrs by using Ir 192 source with single plane implantation. The dose rate was approximately 0.45-0.5Gy/hr

Patient characteristics and data

Total no. of patients 6
Mean age in yrs (range) 53 (49–60)
Sex
Male 4
Female 2
Median follow-up period in months (range) 16-18
Stage T1 N0 M0
Radiation modality - Interstitial Brachytherapy with Ir 192 implant
No chemo
No EBRT

Treatment Technique and Execution :

After completion of evaluation like pre anaesthetic check up and fitness for GA and adequate healing of dental sockets following dental extraction. Patient is planned for implantation. Patient is drapped adequqte with standard sterilisation procedure to oral cavity and skin around mouth and neck extending upto the sub mandibular region where catheters are going to be inserted.Under GA with aseptic precaution an average of 4-5 polyethylene cannulas were implanted into base of tumor on tongue via sub mandibular route. Implanted tumour volume is marked on tongur surface.As the polyethylene catheters are inserted through the submental skin and are directed superiorly, the covering submental skin entry points for catheter were similarly marked. Usually seperation between catheters is 1cm apart and fixed with button on both side

Post-implant orthogonal radiographs were taken for each patient on simulator with radio-opaque dummy markers in the implanted catheters Reference points were also marked on the patients' skin at different axial levels, and radio-opaque markers were placed prior to acquiring radiographs. Soon after, cone beam CT images were acquired with 3 mm slice thickness with catheters. The target and critical organs were contoured on the cone beam CT images

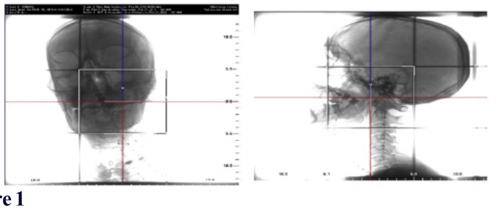


Figure 1
Orthogonal radiographs with X-ray dummy's and radio opaque

reference markers

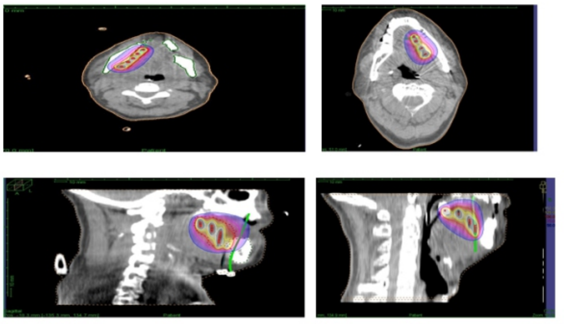
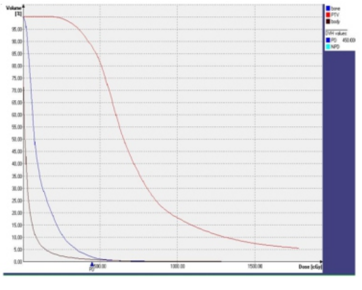


Figure 2
CBCT image containing the contours and radio-opaque reference markers

The geometry of the implanted catheters was reconstructed from orthogonal radiographs, and dosimetry was carried out on Plato TPS as is usually done for conventional planning. All the reference markers were digitized both in x-ray and CT images. Besides external reference markers, radio-opaque buttons on both ends of the implanted catheters were taken as internal reference markers for the subsequent mapping of x-rays and CT data sets. All catheters were loaded with alternate dwell positions of step size 2.5 mm, leaving 5 to 10 mm from the open end of the tube to minimize skin dose. The treatment plan was geometrically optimized and prescribed on the natural prescription dose (NPD) derived from the anderson natural dose volume histogram (DVH). The final plan was then superimposed retrospectively onto the CT data set by co-registering the reference radio-opaque markers of the radiograph with the corresponding reference markers on the CT data sets using coordinate transformation method available with Plato TPS.



Evaluation:
Qualitative evaluation of the dosimetric outcome was carried out by visualizing the mapped isodose distribution in each slice of CT. Quantitative evaluation of the implant dosimetry was carried out using various indices derived from the dose volume relationship of the patient's CT images. The indices included coverage relative dose homogeneity index (HI), conformal index (COIN), dose nonuniformity ratio (DNR) and natural dose ratio (NDR).Mandible 5cc volume dose was also used as a parameter in evaluating the plans.

Dosimetric Indices:
CI is the fraction of PTV receiving a dose equal to or greater than the reference dose:

HI is the fraction of PTV receiving a dose between 100 and 150% of the reference dose:

OI is the fraction of PTV receiving a dose equal to or greater than two times the reference dose:

DNR is defined as the ratio of high-dose volume relative to the reference volume.

DNR = V150 /V100

NDR is a means of quantifying the degree of underdosage or overdosage of a particular implant.

NDR = NPD/PD

where NPD and PD are the natural prescription dose and actual prescription dose of the implant, respectively. NPD is located at the base of the peak of natural dose volume histogram (NDVH).

The COIN takes into consideration the coverage of PTV by the reference dose and also the unwanted irradiation of normal tissue outside the PTV:

In the above equations, PTV_{100} is the volume of target receiving a dose equal to or greater than the reference dose, PTV_{150} is the volume of PTV receiving 1.5 times of the reference dose, PTV_{200} is the volume of PTV receiving equal to or greater than two times the reference dose, V_{100} is the volume of tissue that received reference dose and V_{PTV} is the total volume of PTV.

Parameter	GO *Mean (Std Dev)*
Target V100	79.97(8.0)%
Target V150	31.16(11.1)%
Target V200	6.74(4.4)%
COIN	0.61(0.05)
HI	0.49(0.10)
NDR	1.04(0.06)
DNR	0.39(0.12)
Mandible D5cc	78.53(22.6)%

Dosimetric parameters for the different optimization techniques

Treatment monitoring:
During brachytherapy, patient monitoring is mandatory in order to detect potential displacement of catheters. Adequate analgesics and anti inflammatory coverage was given. Mouthwashes and nutritional support through a nasogastric tube was initiated and started on prophylatic antibiotics in view of secondary infections.

Recommendations for reporting interstitial therapy according to ICRU 58: Description of the clinical conditions, including GTV and CTV

Description of the technique (is the application performed following a system ?)

Source specification, including RAKR (Reference Air Kerma Rate) and TRAK (Total Reference Air Kerma)

Complete description of the time-dose pattern

Treatment description
Mean central dose (MCD), Minimum Target Dose, Homogeneity Index

Volumes and their dimensions, including PTV, Treated Volume, high-dose

regions, low-dose regions, reference volume, irradiated volume (level 2)

Coverage and conformity if possible

Organs at risks

Discussion
Unlike other clinical sites, head and neck implant still remains one of the most complicated procedures because of the complex relationship of anatomical structure with disease. Since the inception of interstitial implants at our center in the year 1970, dosimetry had been carried out using a set of orthogonal radiographs. The dosimetric outcome of the implant was evaluated qualitatively by observing the isodose distribution in three orthogonal planes of the implanted geometry. However, this dosimetric system did not provide a three-dimensional relationship between the implanted volume and the anatomic boundaries of the target volume. As a result, implant quality estimated using Anderson DVH might not necessarily correlate with tumor coverage. Hence, to enable a more clinically realistic evaluation of the implant dosimetry, anatomy (CT) based dosimetry need to be adopted. A very limited number of articles on CT-based dosimetry of interstitial implants have been reported; mostly, these have been for breast cancer.[1–4] At the time when 3D CT-based TPS was not available for BT, Vicini *et al*.[1] retrospectively translated the source positions and

dwell times planed on 2D BT TPS (Nucletron) using radiographs onto the CT data set of the same patient on a different 3D TPS (ADAC Pinnacle) for quantitative evaluation.

In our proposed technique, more complicated implant geometry was tested using a single TPS and coordinate transformation method. Moreover, in most of the reported studies, only few dosimetric quality parameters related to coverage and homogeneity were addressed. Though modern TPS's support reconstruction of catheter in multiple CT reconstructed plane, our Plato TPS did not have this option at the time of this study.

The maximum variation between the corresponding reference markers during the coordinate transformation was observed to be 1.5 mm. While performing coordinate transformation, out of many reference internal and external markers, those which resulted in least variation were selected for the final mapping. The projection of the catheters represented by a train of active sources was verified on the CT images. A maximum dosimetric inaccuracy of 1.6% was reported by Vicini *et al*.[1] as a result of ±2 mm mismatch in the implant template when transformed from x-ray to CT data set.

The mean CI (0.81) estimated in our study was less than 0.95, as reported by Major *et al*.[8] for ideal implant geometry. However, our mean CI is in agreement with the value suggested by Baltas *et al*.Das *et al*. also reported a CI value of 0.96 in a series of early-stage breast cancer patients treated with image-guided interstitial implant technique for accelerated partial breast irradiation. In their study, graphical optimization was used interactively to achieve higher dose conformality to the target volume. However, the interactive optimization may perturb the homogeneity and lead to an increase in OI. The data from our dosimetry may not be comparable directly with other's data as most of the studies were reported for breast cancers. Higher values of EI in our study indicate larger volumes of normal tissues irradiated by the reference dose. This prescription dose volume to surrounding normal tissue could be avoided if the active source-loading is performed based on the target volume delineated from CT rather than deciding the active length from the radiograph. The value of EI reported by Major *et al*. for idealized implants ranged from 0.17 to 0.44 for various dosimetry systems.

Our mean value of HI (0.65) is in good agreement with the finding of Major *et al.*They reported mean HI of 0.68 for an ideal implant geometry using stepping source dosimetry system. The maximum estimated value of OI is 0.06, and it is well below the reported value (0.11-0.13).The lower value of COIN in this study is due to larger normal tissue irradiated by the prescription dose. Conformal dosimetry system (CDS) developed by Baltas *et al*.Aimed to achieve a COIN value above 0.64. However, COIN values reported by several authors ranged from 0.48 to 0.76.[5-8]

Conclusion

The proposed technique of 'cone beam CT image'-based evaluation of a radiograph-generated plan for interstitial implant is a promising approach in the absence of multiplane catheter reconstruction software. This technique is feasible and accurate even for the most complicated implant geometry. It also allows the physicist and physician to evaluate the plan both qualitatively and quantitatively to achieve desired conformity as well as homogeneity without compromising on reconstruction accuracy. Dose volume indices derived from CT data set are useful for evaluating the implant as well as comparing different brachytherapy plans. COIN index is an important tool to assess the target coverage and sparing of normal tissues in brachytherapy.

Even though target coverage was adequate in orthogonal image based planning, the CBCT verification resulted in modification of dwell time and source positions to avoid excess dose to mandible in certain plans. We conclude that conventional orthogonal image based planning is equivalent to CT based planning in terms of target coverage but CBCT based planning can accurately predict the dose to the organs at risk (mandible).

References

1. Vicini FA, Kestin LL, Edmundson GK, Jaffray DA, Wong JW, Kini VR, et al. Dose volume analysis for quality assurance of interstitial brachytherapy for breast cancer. Int J Radiat Oncol Biol Phys.1999;45:803–10. [PubMed]
2. Das RK, Patel R, Shah H, Odau H, Kuske RR. 3D CT based high-dose-rate breast brachytherapy implants: Treatment planning and quality assurance. Int J Radiat Oncol Biol Phys. 2004;59:1224–8.[PubMed]
3. Cuttino LW, Todor D, Arthur DW. CT-guided multi-catheter insertion technique for partial breast brachytherapy: Reliable target coverage and dose homogeneity. Brachytherapy. 2005;4:10–7.[PubMed]
4. Kolotas C, Baltas D, Zamboglou N. CT-based interstitial HDR brachytherapy. Strahlenther Onkol.1999;175:419–27. [PubMed]
5. Anderson LL. A "natural" volume-dose histogram for brachytherapy. Med Phys. 1986;13:898–903.[PubMed]
6. Meertens H, Borger J, Steggerda M, et al. Evaluation and optimization of interstial brachytherapy dose distributions. In: Mould RF, Battermann JJ, Martinez AA, Speiser BL, editors. Brachytherapy from radium to optimization. Veenendaal, The Netherlands: Nucletron International; 1994. pp. 300–6.
7. Baltas D, Kolotas C, Geramani K, Mould RF, Ioannidis G, Kekchidi M, et al. A Conformal Index (COIN) to evaluate implant quality and dose specification in brachytherapy. Int J Radiat Oncol Biol Phys. 1998;40:515–24. [PubMed]
8. Major T, Polgar C, Fodor J, Somogyi A, Nemeth G. Conformality and homogeneity of dose distributions in interstitial implants at idealized target volumes: A comparison between the Paris and dose-point optimized systems. Radiother Oncol. 2002;62:103–11. [PubMed]