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FEASIBILITY OF TREATING SUPERFICIAL COMPLEX TARGETS USING ADVANCED RADIATION THERAPY PLANNING

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Abstract : Aim Superficial targets are those which either is on skin surface or within 1-2cm of skin surface. Complexity arises if the target is widespread and situated in conjunction with vital normal structures. Here we discuss three situations, were we used megavoltage photons to treat scalp, face and combined scalp and face lesions. Materials and methods -One case is a verrucous carcinoma of scalp after excision of the tumours treated with radical radiat ion. He had good response with radiation and is on regular follow up. Next one is peripheral T cell lymphoma of the face which was resistant to chemotherapy. He also had excellent response to radiation and good palliation of symptoms, but due to the biology of the disease, he developed widespread disease. And a rare angiosarcoma of face and scalp, who was inoperable, and underwent PET-CT based planning for his lesion. He had satisfactory regression of the lesions.

Results - Good target coverage with acceptable normal tissue constraints was achieved in all the three cases and there was a good clinical regression of the tumours. Thus with modern planning techniques, complex targets can be treated adequately.

Conclusion - With improved technology complex superficial targets can be treated adequately with high energy photon beams.

Keyword :Dosimetry superficial PTV IMRT VMAT

INTRODUCTION:

Dosimetric uncertainty of the surface becomes major issue while treating superficial region such as face. Inadequate dosage to the PTV along with increasing dosage to the OAR is common while using conventional and electron beam radiotherapy. Newer modalities like IMRT, VMAT overcomes these hurdles and provide dramatic response when used for treating superficial complex targets like face, scalp by sparing OAR provide homogenous dose distribution throughout the lesion.

METHODS AND MATERIALS:

Three cases with superficial wide distribution over the face and scalp has been selected .The first patient is an elderly male diagnosed as a case of cutaneous angiosarcoma,of face and scalp treated with volumetric arc radiotherapy, the second patient is a case of cutaneous B-cell lymphoma of face for whom intensity modulated radiotherapy has been chosen.The third patient is a case of verrucous carcinoma of scalp for whom intensity modulated radiotherapy has been chosen as the modality of therapy.

CASE DESCRIPTION:

CASE1:

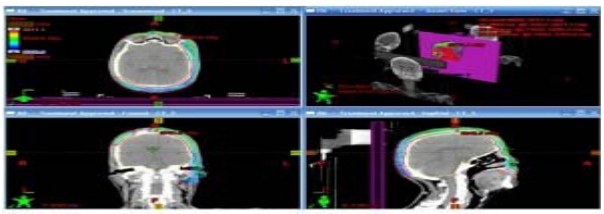
65yrs old male came with c/o pain and swelling over the face and scalp examination revealed well defined hyperpigmented woody hard non-tender swelling involving left eyelid and encircling the orbit. There was swelling of both eyelids present and erythematous plaque over both postauricular area. Peau-de-orange appearance of the skin over the forehead was

present.

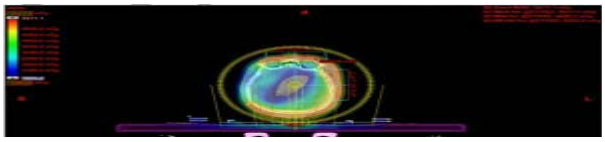
HPE (with IHC correlation) S/O : angiosarcoma.

Spiral CT shows swelling in the left eyelid which is more extensive over the left side extending into temporal and pre-maxillary region, mild soft tissue swelling in the right periorbital region. PET-CT shows abnormal increased tracer uptake noted in the irregular diffuse thickening in the left eyelid involving ipsilateral periorbital and pericranial subcutaneous regions(SUV 4.0) and irregular lobulated soft density lesion in the pericranial occipital region(SUV 9.2) .Neck nodes level IIA (SUV 2.8), both level III (SUV 2.5) left level VA,VB (SUV 2.1) and level IV- supraclavicular (SUV 2.9) region. Because of the aggressiveness of the lesion treatment options are found to be limited. Radical excision of the lesion is found to be the common modality of the treatment. Since the lesion is found to be extensive surgery was not possible and radiotherapy was planned. Aquaplast mould was done, wax bolus was prepared to match irregular facial contour. Mould was prepared along with bolus so that dosimetry will be even.

PET-CT based plan was done. Target volume contouring was done based on standardized uptake value. Other organs at risk such as eye, opticnerve, optic chiasma ,brain, spinalcord were also contoured. Volumetric modulated arc therapy was planned. Dose verification was done using phantom and then treatment was executed. Treated with DD 180cGy for TD of 5040cGy.Satisfactory regression of the lesion and palliation of pain was achieved.



VMAT PLAN



CASE 2:
71 yrs male was diagnosed as a case of peripheral Tcell lymphoma Stage IV (agressive). He presented with a 6x5cm nasal swelling reddish and mild erythema present along with right sided m preauricular node and another swelling on right side 0.5cm below the eyebrow.Right sided node at the level of angle of mandible present.right sided level III nodes present.

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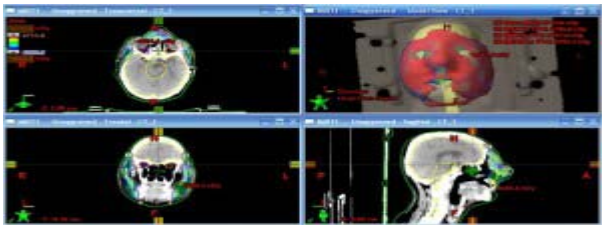
HPE(with IHC correlation) s/o : peripheral T cell lymphoma with aggressive histology. Spiral CT PNS/neck showed soft tissue swelling in the nose towards proximal aspect of the left side of the nose. The lesion slightly indented over the extraconal space of left orbit abutting the eyeball, Another nodule of size 14mm was seen over left cheek.Bilateral level II and level III cervical lymphnodes present. Since the lesion is resistant to chemotherapy palliative radiation was considered as a treatment option. Aquaplast mould was done. Target volume contoured based on CT plan.Other organs at risk like brain,spinal cord, optic nerve both right and left, optic chiasma were contoured along with the lesion. Intensity modulated radiation therapy was planned. Dose verification was done using phantom and then treatment was executed.RT to a total dose of 50Gy was given to the lesion.Patient developed good response to radiation but developed widespread disease due to the biology of the disease.

AQUAPLAST MOULD DONE



CASE 3:
38yrs old male presented with multiple verrucous leision over the entire scalp with 3 verrucous growth in right parietal,occipital,left parietal regions treated with wide local excision and split skin grafting elsewhere.
The treatment available for the patient is
A) Photon -Electron 3DCRT
B) Helmet mould -based HDR
C) LINAC -based segmental IMRT.

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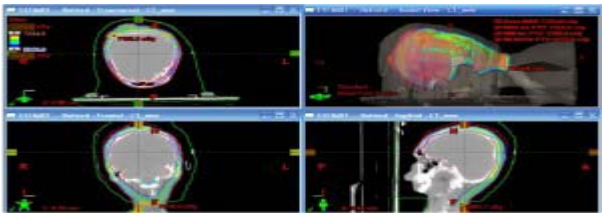
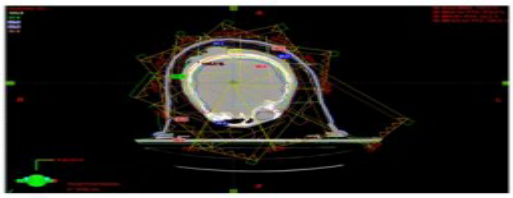
A) Photon -Electron 3DCRT
B) Helmet mould -based HDR
C) LINAC -based segmental IMRT.
The Photon-Electron technique has the longest history and spares the optical structures, but involves troublesome field matching and dose heterogeneity. The HDR technique is the most conformal and simple to deliver, but is limited to target dose in homogeneity. IMRT technique offers the best target coverage and the most homogenous and conformal dose distribution with only a moderate increase in dose to the optical structures but within a clinically acceptable level. So he was treated with 6MV Xraybeam therapy to the whole scalp using IMRT technique.

Custom made bolus and immobilisation device was done. CT for RT planning was done using 3 mm cuts. IMRT planning was done. After QA plan was executed. Excellent regression of the scalp lesion was achieved. He is on regular followup now with no evidence of recurrence.



11FIMRT SETUP FOR THIS PATIENT



DISCUSSION:

Choice of treatment available were

1) Conventional orthovoltage photons
2) Brachytherapy
3) Electron Beam Therapy
4) Megavoltage beam therapy with IMRT , VMAT.

Conventional orthovoltage photons used in the treatment of superficial lesions which has its own advantages that it can be used with thin shielding of normal tissues with higher relative biological effectiveness. But it has its own disadvantages that it cannot be used for larger irregular lesions. Optimal dose cannot achieved at the curved surface which leads to less coverage at curved surface and finally less treatment depth achieved. Brachytherapy has its own advantages of normal tissue sparing with increase dose to the tumour as per inverse square law. Though dose distribution is superior to conventional orthovoltage photons it has difficulty in achieving better coverage in larger,irregular thicker lesions. Further it depends of the skill of the specialist in achieving good dose distribution. Electron beam therapy can also be used since appropriate energy can be selected which helps in achieving dose distribution with rapid dose fall off beyond the required field. But it has its own disadvantages such as it requires multiple fields and it is less effectively reproducible that leads to clinical error, field matching will be difficult which leads to cold and hot spots.

Eye shielding is difficult since there is lateral scatter radiation, lesions involving complex surfaces such as sinuses should be avoided and difficulty in using in curved surfaces. Finally it is time consuming which makes its usage in hospitals with heavy patient load. Megavoltage beam therapy such as IMRT,VMAT overcome all the hurdles in other modes of management.It can be used in larger,irregular lesions of various depths which makes it suitable in treating complex targets.Though there are certain difficulties such as its strict requirement inmaintaining quality assurance and having less relative biological effectiveness compared to other treatment techniques its dose distribution is much superior to all other techniques. IMRT is a newer method of delivering radiation to the target structures that differs from the traditional methods.The basis of the IMRT is use of intensity modulated beams that can provide two or more intensity beam level for a single beam direction and from a single source position.Through this plan IMRT are able to generate concave dose distribution and dose gradients to a narrow margins than those allowed using tradistional methods.This fact making IMRT specially suitable for treating complex superficial structures treatment volumes and avoiding close proximity organs at risk that may be limiting to conventional modality of trearment.It must be noted that the total dose delivered through IMRT is same as that of conventional method but the outcome will be excellent when compared to conventional methods. This is clinically evident in calculating homogeneity index and calculating dose to organ at risk.

HOMOGENEITY INDEX:

The dose distribution in these plans can then be visualized in the form of dose-volume histograms (DVHs) and isodose lines, to define parameters like maximum dose (Dmax), minimum dose (Dmin), mean dose (Dmean) and modal dose delivered to each volume of interest. Unfortunately, the large volume of data contained in these histograms, lines and curves may complicate the problem rather than simplifying it. This makes it desirable to have a tool that can integrate this data in a simpler way to quantitatively assess the quality of the treatment plan options. By using such a tool we can make a choice in favor of a plan which provides maximum tumor

coverage homogeneously and protects healthy tissues at the same time. The homogeneity index (HI) and the conformity index (CI) are two such tools for treatment plan analysis in conformal radiotherapy. A more descriptive formula is HI = D2-D98/Dp×100; where D2 = minimum dose to 2% of the target volume indicating the “maximum dose”, D98 = minimum dose to the 98% of the target volume, indicating the “minimum dose” and Dp = prescribed dose. This is the most commonly used formula in the literature. The reason for choosing D98 and D2, to represent the minimum and maximum dose, is that the calculation of true minimum or maximum dose is sensitive to the dosecalculation parameters.This is the reason for choosing the maximum or minimum dose in a volume (D 2, D98 etc.) rather than at a point. Thus, in all definitions, HI basically indicates the ratio between the maximum and minimum dose in the target volume and the lower value indicates a more homogenous dose distribution within this volume.

Homogeneity index shows excellent uniformity in dosage throughout the tumour. This is understood by the fact that

CASE	D2	D95	D98
Cutaneous Angiosarcoma	55Gy	47Gy	45Gy
Peripheral T-cell Lymphoma	44Gy	40Gy	39Gy
Verrucous Carcinoma	62Gy	57Gy	54Gy
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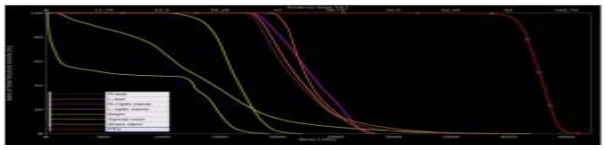
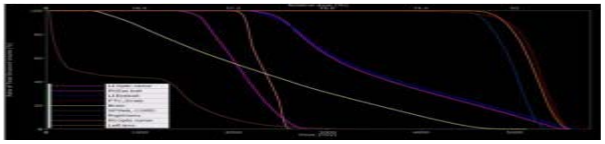
ORGAN AT RISK:

Further critical organ sparing was excellent even with extensive leisions on proximity to critical organs this was evidenced by DVH.

DOSE VOLUME HISTOGRAM Cutaneous Angiosarcoma



Peripheral T Cell Lymphoma



Verrucous carcinoma Scalp

Organ At Risk	Max Dose	Case 1	Case 2	Case 3
L.Optic Nerve	55 Gy	2289cGy	2288cGy	2300cGy
R.optic Nerve	55 Gy	2283cGy	2288cGy	2400cGy

Brain	<50Gy	23Gy	22Gy	24Gy
Spinal cord	45Gy	821cGy	747cGy	37Gy

Given the potential dosimetric advantages it has improved target coverage in areas with difficult volume to treat which may translate into an increase in local control with ability to increase maximum tumour dose.Hence it could be considered as a viable treatment option as it is considered ethical that it provides little harm compared to original method.

CONCLUSION:

IMRT and VMAT offers best target coverage and most homogenous confirmed dosage distribution as evidenced above with very minimal dosage to the critical organs such as brain,spinal cord,optic nerve therby sparing organ at risk.

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