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Case Report

Total Scalp Irradiation : Benefits From Optimisation Of Customised Bolus With Volumetric Arc And Electron Combination Therapy.

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INTRODUCTION

Total scalp irradiation is used to treat melanoma, lymphoma, angiosarcoma, mycosis fungoides, basal, and squamous cell carcinoma. Treatment of the total scalp is typically reserved for diffuse disease presentations, recurrences and its intent is mostly palliative[1-5].

Planning and delivering radiation treatment to whole of the scalp is technically challenging due to the geometry of the head and the close relation of the scalp to the brain, optical structures, and other nearby healthy organs at risk. The main challenge of scalp irradiation is to deliver a homogenous dose while sparing the normal brain and other healthy structures. The thickness of scalp is only 4–6 mm, so traditionally electrons have been the modality of choice because of its high surface dose, rapid dose falloff and its finite range, with acceptable dose received by the brain resulting in only minimal treatment-related toxicity. Nonetheless, electron treatments have its own difficulties in terms of the scattering of electrons at oblique surfaces which can create unusual dose distributions[6].

Many techniques using photons and mega voltage electron beams have been described in the literature. Most of the techniques have used photons obtaining a good conformation of dose to target and protection of surrounding normal tissue as well[7-11]. Techniques such as static electron fields, electron arc therapy, intensity modulated electron radiation therapy, helmet mold-based surface brachytherapy, volumetric arc therapy and helical tomotherapy have been used worldwide.

In this report, we describe a combination of volumetric arc therapy technique and electron therapy for boost for a patient with recurrent tumours in scalp.

CASE REPORT

An 68-year-old woman presented with a history of multiple recurrent skin lesion in the scalp, initially operated in an outside institution. The first documented occurrences date back to December 2019, at which time she underwent excision biopsy of occipital lesion. Pathology confirmed that the lesion was basal cell carcinoma (BCC). In 2021, she underwent wide excision with primary closure of parietal and occipital lesion which on histopathology showed pseudo-sarcomatous lesion. In august 2022 , she came with swelling behind the left ear for which excision biopsy was done . On histopathology it was metastasis from skin adnexal carcinoma likely endocrine - mucin producing sweat gland carcinoma with IHC positive for GATTA 3 , CK7, Pan CK and synaptophysin . Patient was was referred for the consideration of radiation therapy to scalp and cervical lymph node .

Patient was asked to shave the head before coming for simulation . On the day of simulation first a 5 mm wax bolus helmet was made along with immobilisation cast (**Figure 1**).Simulation was performed with 3 mm cuts in a SOMATOM Definition AS 64 slice CT scanner (Siemens Medical Systems®). The clinical target volume (CTV) included the skin surface to the depth of the cranium over the extent of the patient's scalp . The planning target volume (PTV) was delineated as the CTV plus 3 mm margin.The 50.4Gy was prescribed to the PTV

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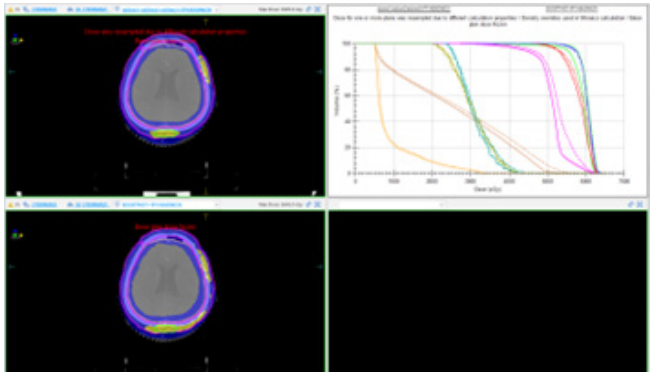
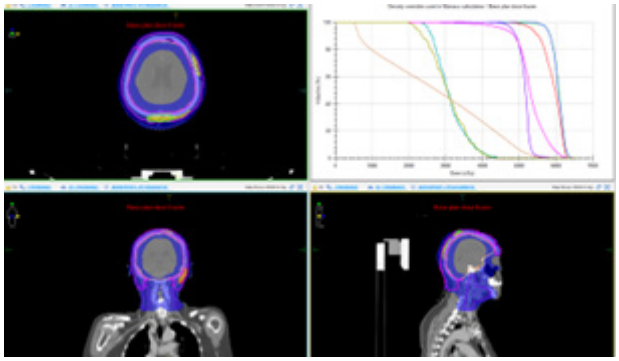
followed by a 9 Gy boost to the scars.The 0.5cm bolus was used in both phases.The treatment was delivered on the ELEKTA SYNERGY PLATFORM using 6 MV X-rays. Cone beam CT was used prior to every fraction for daily position verification. Patient specific QA was performed . The volumetric arc therapy (VMAT) plan was generated using two half-field arcs . Details of each arc are described in **Table 1** and shown in **Figure** . The total number of monitor units (MU) per cGy was 5.3 MU/cGy.

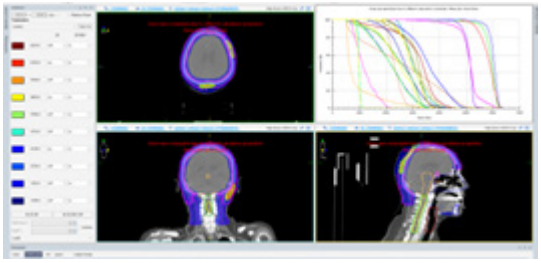
Table 1.

Arc	Couch position (deg)	Collimator	Gantry rotation (degree)	Monitor units/ fraction
Arc 1	350	0	180-180	470.26
Arc2	10	0	0-180	484.02

Figure 1.







Boost of 9 Gy was planned for scar on occipital , parietal and post auricular region . Boost was planned with both electron and photon . The D95 for VMAT+electron boost and VMAT + photon boost were 97%. As expected, V95 also yielded similar results, being 98% for both plans. Mean dose to brain was 27.4 Gy with photon boost and electron boost was 25.81. The dose volume histogram (DVH) of both plans , demonstrated good coverage and a homogeneous dose within the target with acceptable dosage of the organs at risk.

Table 2.

	Combination of photon + photon boost	Combination of photon + electron boost
PTV	Dmax (0.035cc) - 64.34 Volume recieving 107%dose - 0.01cc	Dmax - (0.035cc) - 63.21 Volume recieving 107%- 0.3cc
Right eye	Dmax 37 Gy mean 21.2 Gy	D max 36.1 Mean 21.37
Right lens	D Max 11.2Gy Mean 9.8 Gy	D Max10.3 Mean 9.63
Right optic nerve	Dmax 40Gy Mean 31.8	D max 36.9 Mean 29.5
Left eye	Dmax 38 Mean 21.6	D max 38.1 Mean 21.6
Left lens	D max 11.4 Mean 10.4	D max10.4 Mean 9.8
Left optic nerve	Dmax 40.3 Mean 35.9	Dmax 40.3 Mean 35.9
Brain	Mean 27.4 V40 Gy - 26.8 cc	Mean 25.81 V40 Gy- 22.4 cc

DISCUSSION

Involvement of Scalp and calvarium is not very common in conditions such as squamous cell carcinoma , angiosarcoma , lymphoma , melanoma , endocrine mucin producing sweat glands. Infrequently, widespread involvement requires total scalp irradiation. Our patient is a case of recurrent scalp tumour underwent surgeries outside our institutions and unfortunately the previous slides were not available for review . Initially it was reported as basal cell carcinoma then pseudo-sarcoma and in last surgery it was reported as endocrine mucin producing sweat gland carcinoma. In view of recurrent tumors , patient was planned for total scalp irradiation and neck irradiation. Total scalp irradiation is a very complex technique, and still electron field radiotherapy and brachytherapy techniques are considered as the gold standard therapeutic modality. Electron techniques require laborious setup, and authors like Chan et al have documented its inferior homogeneity across the target volume, which could lead to inferior results[12,13].

Brachytherapy, although reported to be the most conformal technique of all, demands an even more complex setup. The sole treatment with mould surface brachytherapy for such an extensive lesion, one should also bear in mind the inherent flaws, such as mould-skin air gaps and skin surface dose inconsistencies, when PTV has a depth of more than 5 mm. Moreover, due to the need for neck radiotherapy, this method was unfavourable.

In an attempt to address the inhomogeneous dose distribution , IMRT ,VMAT and helical Tomotherapy are currently utilised for scalp irradiation. These techniques have reported homogenous dose distribution over the scalp while reducing the irradiated dose and volume of Organs at risk[10-12,18].

Recently, Sharma et al published dosimetric comparison of proton versus IMRTin total scalp irradiation. In his study it was seen that Total scalp irradiation delivered with Proton offers additional advantages. Homogenous dose to the skin is easily delivered, eliminating the need for a bolus, which can be difficult to construct and secure on the complex scalp surface. Delivery of TSI with proton is much simpler .Disadvantages of proton therapy includes low accessibility and higher cost than IMRT/VMAT .Another important consideration includes the end-range uncertainty of the proton beam[19] .

In our case also we planned total scalp and neck irradiation using VMAT technique followed by boost to scar with electron boost. For comparison we made a plan with photon boost also. This exceptionally rind-shaped PTV plus cervical node irradiation was a challenge to obtain acceptable target dose coverage and dose homogeneity. Nevertheless, both plans provided equivalent target dose coverage. Both techniques

also demonstrated good normal tissue sparing capability. However, the VMAT+ electron boost plan exhibited an advantage in further reducing the doses to the brain
The advantages of combination of VMAT and electron boost treatment for scalp lesions are easy to plan, faster daily set-up and treatment delivery, and simpler dose calculations .
The main disadvantage of VMAT treatment is the increased percentage of low-dose radiation received by the underlying brain, which is significantly higher than other techniques. However, this dose is still typically below the acceptable dose tolerance range and is often associated with no significant acute or late toxicity .

CONCLUSION

VMAT with electron boost provides more homogenous dose distribution within the scalp with reduced mean dose to brain as compared to VMAT with photon boost.In the absence of electron arc therapy , VMAT in combination with electron boost can be a better treatment modality for rind shaped target.

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