Evaluation of Knowledge-based planning of Volumetric Modulated Arc Therapy for Nasopharyngeal cancer

Kishore Joshi[1,4], Jamema Swamidas[1,4], Sarbani Ghosh Laskar[2,4], Subhabrata Ghosal[1,4], Jeevanshu Jain[1,4], Reena Ph[1,4], Shrikant Kale[3,4], Naveen Mummudi[2,4], JP Agarwal[2,4]

[1]Department of Radiation Oncology, Advanced Centre for Treatment Research and Education in Cancer (ACTREC), Tata Memorial Centre (TMC), Navi Mumbai.

[2]Department of Radiation Oncology, Tata Memorial Hospital, TMC, Mumbai

[3]Department of Medical Physics, Tata Memorial Hospital, TMC, Mumbai

[4]Homi Bhabha National Institute, Mumbai.

* Corresponding author: **kj61288@gmail.com**

Background and Objective

- The challenge in delivering radiotherapy for Nasopharyngeal carcinoma (NPC), is the proximity of the tumour to organs at risks (OARs).
- Knowledge based planning (KBP), a model built on a library of previously created treatment plans has been reported to produce high quality consistent plans [1].
- The aim of the current study was to investigate knowledge based predictive models, for treatment planning, for NPC.

Methods

- 73 previously treated NPC clinical treatment plans (CP) of VMAT with simultaneous integrated boost (SIB) were used to configure a KBP model (Rapid Plan, Varian medical system v13.5) [2].
- All plans consisted of two targets, primary PTV (PTV 66), and nodal PTV (PTV 54) with a dose prescription of 66, and 54 Gy in 30 fractions respectively. Optimization objectives for the PTVs and OARs were generated and optimized iteratively.
- The OAR structures modelled were as follows: spinal cord, brainstem, planning risk volume (PRV) brainstem, PRV spinal cord, eyes, parotid glands, oral cavity, optic chiasm, and optic nerves.
- Model quality was quantified by the coefficient of determination R2, goodness-of-fit statistics $\chi2$ and by the goodness of estimation mean square error (MSE) between the original and the estimate.
- Model validation was carried out on a subset of 14 patients, not included in the training data base, by comparing the knowledge-based plans using single optimization without any manual intervention during optimization, and CP.
- Various dose-volume parameters were evaluated for both target and OARs to compare CP vs KBP.
- Wilcoxon single rank test and paired t - test was used to establish the statistical significance between CP and KBP (SPSS v21).

Results and Discussion

- Estimation capability of the model was good for optic nerves and optic chiasm (MSE = 0.012, R2 = 0.89), modest for mandible (MSE = 0.003, R2 = 0.74), brainstem (0.008, 0.65) and eyes (0.007, 0.55). For other OARs, such as spinal cord (R2 = 0.37), parotids (R2 = 0.3) and midline structures (R2 = 0.44) the prediction capability was poor.
- Evaluation of the regression plots and DVH estimation band confirmed the above findings, wherein, the estimation bandwidth was narrow for optic nerves, optic chiasm, mandible, brainstem and eyes as compared to spinal cord, parotids and midline structures.
- The overall observation about target coverage was that KB plans resulted in comparable plans for both target coverage and conformity as compared to CP.
- Most of the DVH parameters related to target structures were found to be statistically not significant comparing CP vs KBP, however, KB plans resulted in moderate homogeneous and conformal dose as compared to CP (PTV 66, D2cm3 p = 0.001, PTV 54 p = 0.012).
- For OARs, KBP resulted in statistically significant sparing for spinal cord (p=0.035) and eyes (p=0.004) as compared to CP, otherwise, for all other OARs, KBP resulted in comparable plans with no statistical significance (Fig 1)

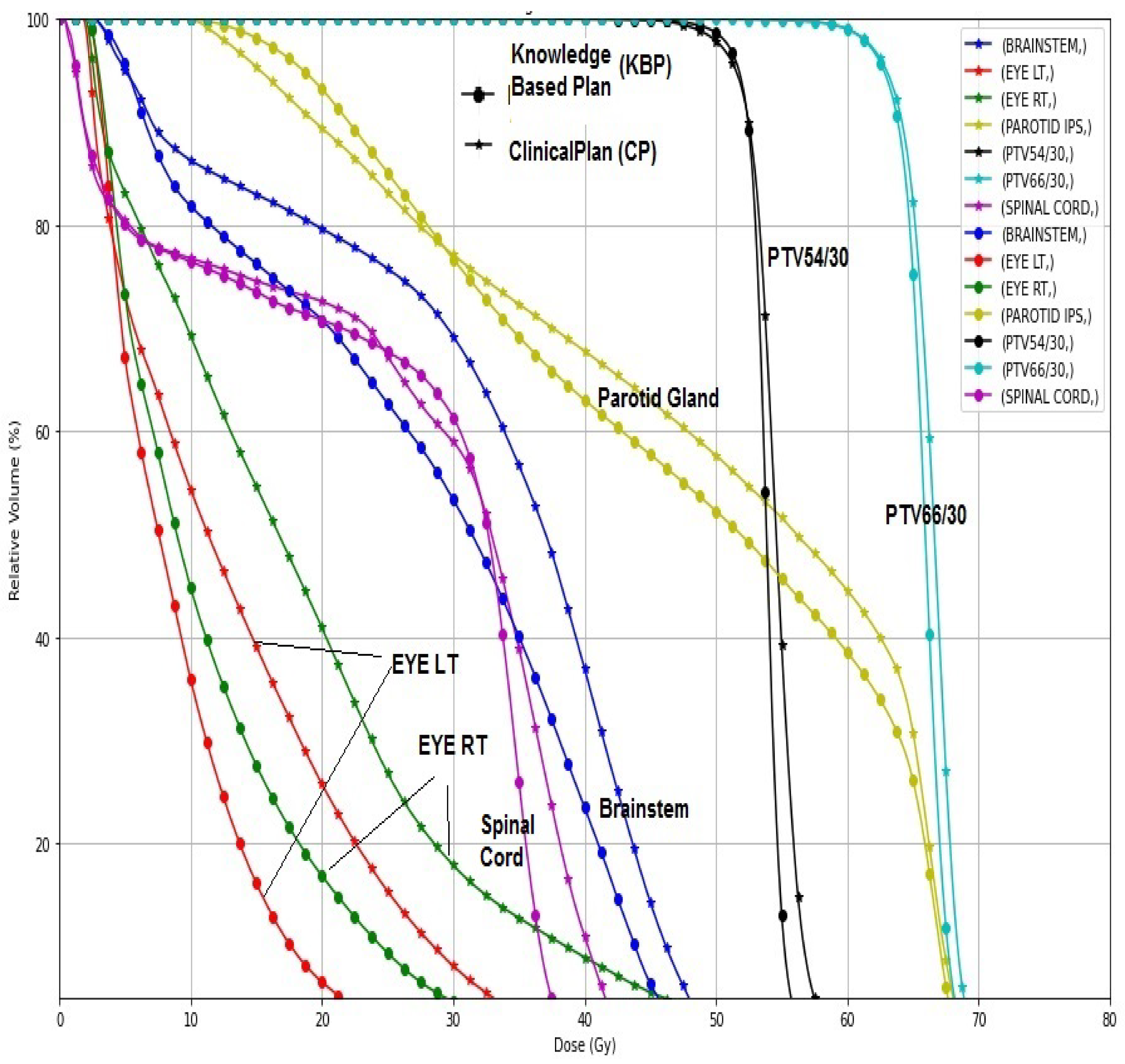

Fig 1: Average DVH comparison between KBP and CP plans for target structures and for some salient OARs.

Conclusions

- A KBP model was built and validated for NPC, to be used for VMAT, for multi-target and dose prescription involving SIB technique.
- Based on the results, KBP was comparable, and for some OARs even outperformed as compared to clinical plans, while producing conformal, homogeneous target coverage, in a time-efficient manner.
- Further validation studies to improve the scope of the model are underway. Efforts are also underway to improve the prediction capability for parotids and spinal cord, by further curation of the training data set.

References

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[2] Eclipse Photon and Electron Reference Guide, Varian Medical Systems.