

# First Investigation on the Dosimetric Perturbation due to the Dental Implants in Spot-Scanning Proton Arc (SPArc) Therapy Planning Strategies

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## Introduction

Radiation therapy (RT) is a common way to treat head and neck cancers. Modern technologies such as VMAT and IMRT have been an aid in decreasing side effects. Recently, IMPT has shown significant improvement in head and neck cancer treatment compared to IMRT. An issue that arises in proton therapy for head and neck patients' treatment planning is the uncertainty of dental fillings. On average, American adults have three dental fillings per person and 84% of adults who live in Britain have at least one tooth filling. With photon radiation it is common to override these densities while still directing radiation through them. The future of proton therapy is up for debate, with some experts believing FLASH-RT is a promising future while others argue that spot-scanning proton arc (SPArc) therapy is more promising. The interest in applying SPArc technique for HNC is high, there is no research done to investigate the potential dosimetric impact from the dental fillings during the SPArc plan generation which could impact treatment delivery accuracy.

## Methods

A published in-house developed SPArc (Spot-scanning Proton Arc) optimization algorithm was used to generate the proton arc plan. The algorithm includes control point resampling, energy layer redistribution, energy layer filtration and energy layer (EL) resampling. Dental fillings were contoured by hand, using density table to help verify and then fillings were overridden to the proper Hounsfield unit. A separate contour adding a 5 mm margin around the dental fillings was created.

Patient criteria included patients with advanced stage bilateral head and neck lymphadenopathy. Dental sparing SPArc plan involved an avoidance sector between 300 and 60 degrees to limit radiation going through the dental fillings. Original SPArc plans were generated without dental filling avoidance function. Dental fillings were overridden as titanium (physical density 4.54 g/cm<sup>3</sup>) during the initial plan. We hypothesize that dental fillings are not well known and shooting through the dental fillings may cause unnecessary target coverage if the material components are not the same as the initial plan. In the dose perturbation evaluations, the dental fillings were overridden to stainless steel (physical density 7.95 g/cm<sup>3</sup>) and compared to the nominal plans. Initial nominal plans were compared to the dose perturbation in terms of OAR dose, conformity index and target coverage to access the plan robustness in case of the uncertainties from the material overridden density.

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## Results

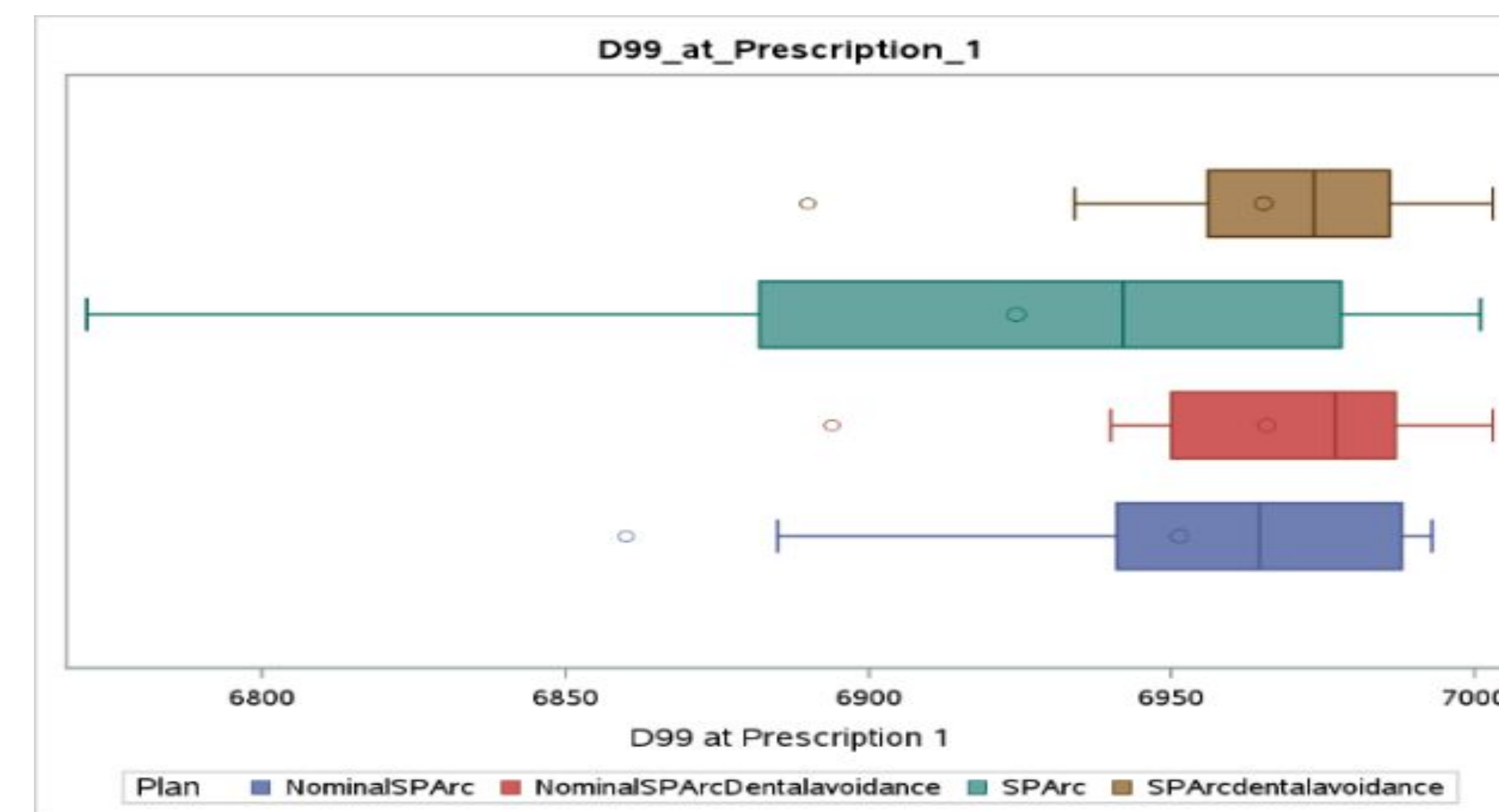


Fig 1. Two-tailed t-test comparison of D99 for 70 Gy prescription in Nominal SPArc, Nominal SPArc Dental Avoidance, SPArc and SPArc dental avoidance plans. Box and whisker plot, boxes display lower 25% of data, mid 50% and upper 75% of data

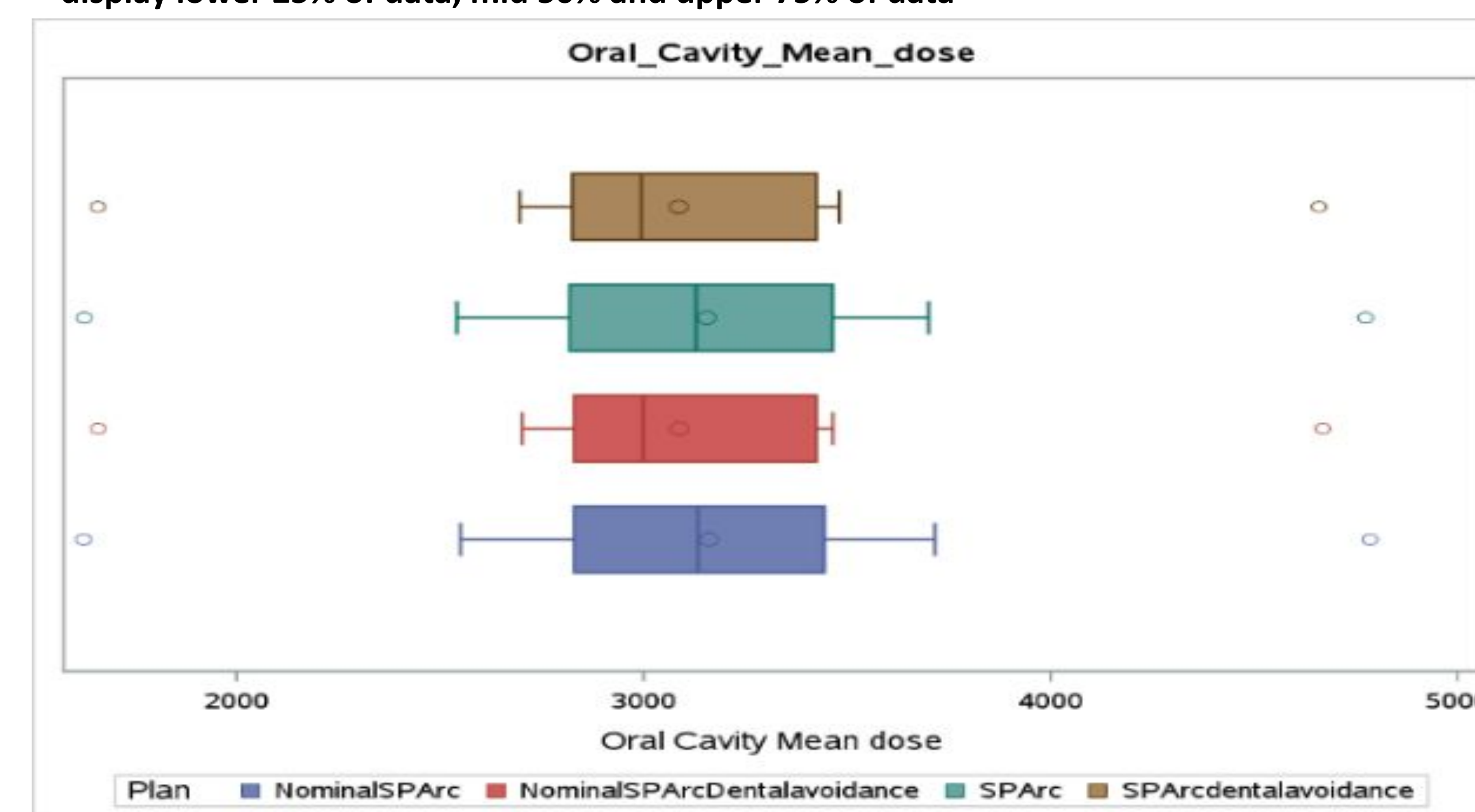


Fig 2. Two-tailed t-test comparison of mean oral cavity dose in Nominal SPArc, Nominal SPArc Dental Avoidance, SPArc and SPArc dental avoidance plans. Box and whisker plot, boxes display lower 25% of data, mid 50% and upper 75% of data

## Results

When observing the D99 between perturbed plans for P1 there is a significant difference between the two ( $P = .002$ ). There is a significant difference between the nominal SPArc and perturbed SPArc plans, ( $P = .0391$ ), showing that density of dental fillings is important. The other prescription doses there is a minimal difference between the two eval plans. There is also minimal difference between the two nominal plans and comparing the nominal plan that correlates to the eval plan.

When observing the mean oral cavity dose, the results show no clinical significance.

## Conclusion

This is the first SPArc study to examine the dosimetric issues associated with treating head and neck cancers (HNC) using dental fillings. Compared to SPArc<sub>original</sub>, SPArc<sub>dentalavoidance</sub> had a significant increase in D99 coverage, while having a lesser impact on dental filling density. As SPArc becomes more readily available across the country, the idea of utilizing a dental avoidance sector in patients with dental fillings should be strongly considered.

## Limitations

The study had a relatively small sample size with 10 patients included and there were different treatment planners for some of the original SPArc plans versus the SPArc dental avoidance which leaves room to introduce planning bias. Also, only two types of densities were used. In future studies, the use of other materials, such as gold or silver, could be employed to evaluate the dosimetric difference.

## References

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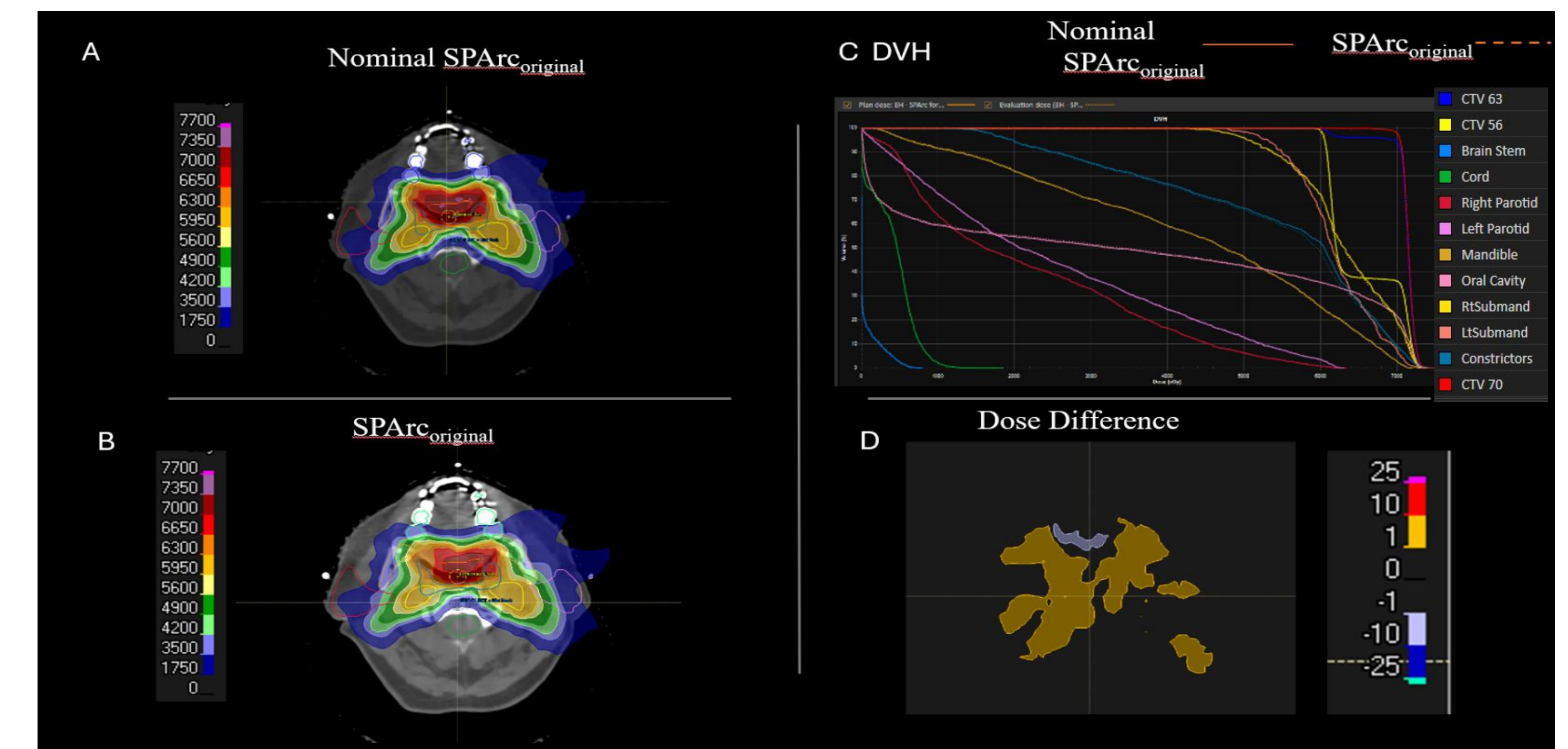


Fig 3. The dosimetric quality and DVH comparison between Nominal SPArc<sub>original</sub> and SPArc<sub>original</sub>. (A) Nominal SPArc<sub>original</sub>, (B) SPArc<sub>original</sub>, (C) DVH shows the dosimetric difference between the two. Nominal SPArc<sub>original</sub> is solid line, and SPArc<sub>original</sub> in dashed line. (D) shows dose difference between the nominal SPArc<sub>original</sub> and SPArc<sub>original</sub> plans.

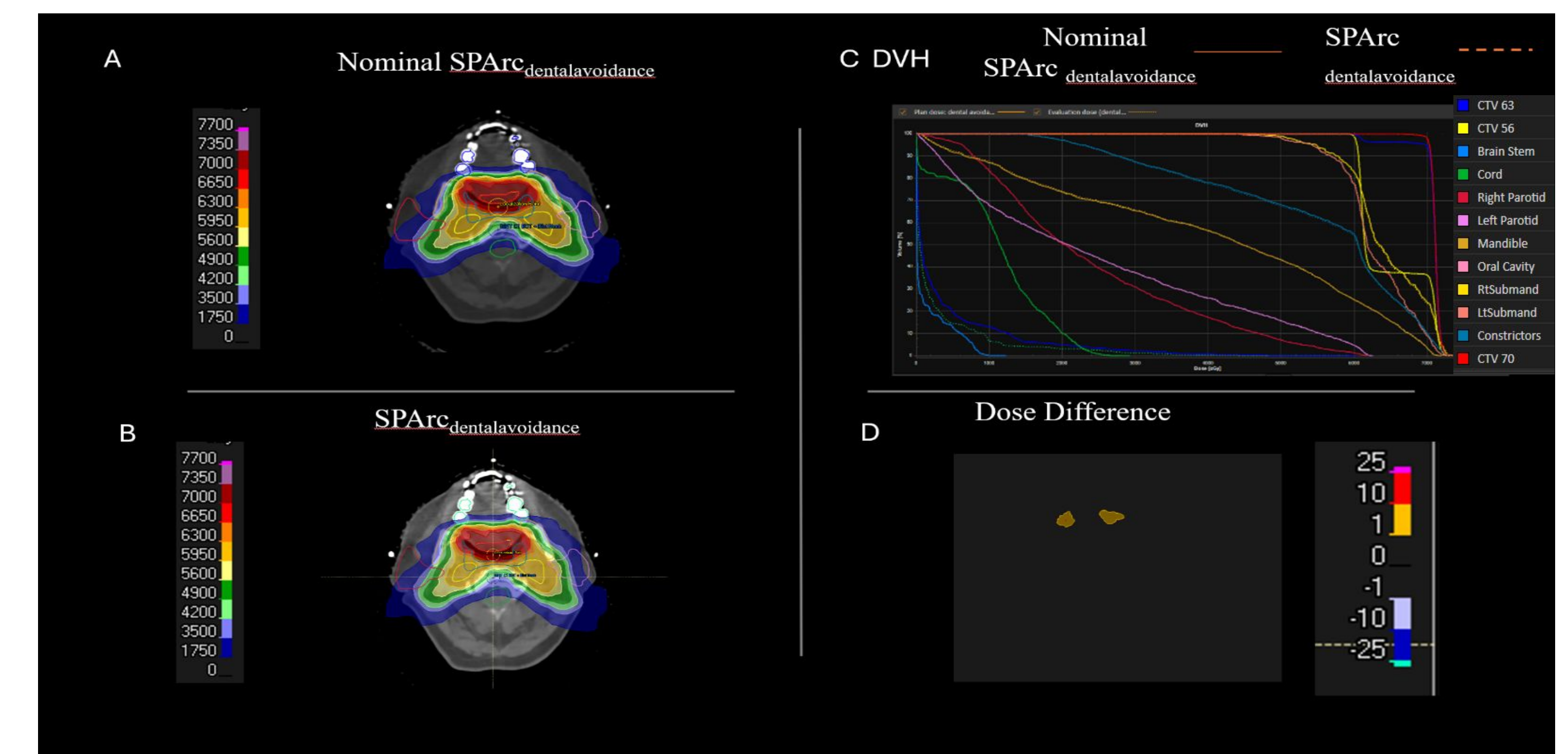


Fig 4. The dosimetric quality and DVH comparison between Nominal SPArc<sub>dentalavoidance</sub> and SPArc<sub>dentalavoidance</sub>. (A) Nominal SPArc<sub>dentalavoidance</sub>, (B) SPArc<sub>dentalavoidance</sub>, (C) DVH shows the dosimetric difference between the two. Nominal SPArc<sub>dentalavoidance</sub> is solid line, and SPArc<sub>dentalavoidance</sub> in dashed line. (D) shows dose difference between the nominal SPArc<sub>dentalavoidance</sub> and SPArc<sub>dentalavoidance</sub> plans.