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Dosimetric comparison of 6 MV FFF and 10 MV FFF beams using cones for Trigeminal Neuralgia Functional Radiosurgery

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Purpose

Trigeminal neuralgia (TN) is a severe facial pain. Radiosurgery (SRS) is one of the main treatment modalities. Linac-based SRS typically uses a cone (physical or virtual), single isocenter, multiple non-coplanar arcs, prescription dose between 80 to 90Gy at Dmax and 6MV beam to improve dose gradient. Total treatment time depend on several factors and dose rate is one of the most important. Due to patient condition reduction of treatment time could be beneficial for those patients.

The purpose of this research was to compare the dosimetric beam characteristics and treatment time delivery of previously treated TN SRS patients with 6 MV FFF beams over 10 MV FFF beams using a conical collimator.

Materials and Methods

Our TN SRS Protocol uses a 6 MV FFF beam by a TrueBeam STx (Varian) with a dose rate of 1400 MU/min, cone of 4mm (Brainlab) and 90 Gy of prescription dose at the isocenter. Patients were immobilized using the Frameless cranial stereotactic mask and the treatment was guided by ExacTrac (Brainlab) for each couch angle. A CBCT was done to check the patient treatment side. The treatment plan was performed using Elements Cranial Cone (Brainlab) with 12 non-coplanar arcs of 110° with a couch separation between 10° and 20°. Elements Cone uses Pencil Beam algorithm and the beam modeling requires data on tissue phantom ratios (TPR), dose profiles (SSD=900mm – d=100mm), and scatter factors (SF, SSD=900mm – d=100mm). Measurements were done using diodes (PTW 60012 & IBA Razor) and EBT3 radiochromic films. IAEA TRS483 correction factors were applied to the SF. Cone beam modeling was done for 6 MV FFF and 10 MV FFF beams with the latter having a dose rate of 2400 MU/min. Reference nominal linac output (square field size: 10cm, SSD: 100cm, d:10 cm and 100MU) is 0.657Gy and 0.744Gy for 6X FFF and 10X FFF respectively. Dosimetric beam dose comparisons between energies were done. Eleven TN SRS plans with 6 MV FFF and 4 mm cones were recalculated with a 10 MV FFF beam using the same isocenter and protocol. Brainstem Dmax, D10%, and V20% of the prescribed dose were used to compare dose distributions plans. Delivery times for a single arc and overall were compared.

Results

TPR for 10 MV FFF beams has an average increment of 10% at a depth of 100 mm compared to 6 MV FFF beams, Figure 1. Dose profiles show an average penumbra (80%-20%) width increment of 0.3 mm [0.26-0.35] for 10 MV FFF beams, Figure 2. The black dotted and black lines represent the SF average value, Figure 3. The SF values are within the reference data range (Brainlab). Treatment plans using 6 MV FFF or 10 MV FFF are within the radiation oncologist acceptance criteria. Treatment planning comparison shows that 10 MV FFF plans have a slight increment of low doses volumes, Figure 4. Total plans MU are similar for both energies. 10 MV FFF plans shows brainstem Dmax (Table 1) and D10% (Table 2) higher than 6 MV FFF. The average increment of Dmax was 6.5% and for D10% 18.1%. The V20% had an average increment of 18.3% for 10 MV FFF plans. Treatment delivery time per arc was 40% shorter using 10 MV FFF as compared to 6 MV FFF. The total treatment delivery time including couch rotation was reduced by 28% using 10 MV FFF. The percentage of time reduction will decrease if image guidance is included.

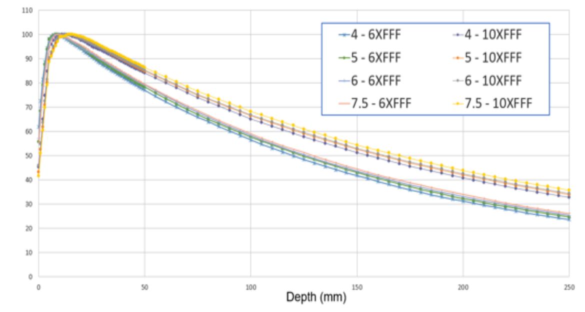
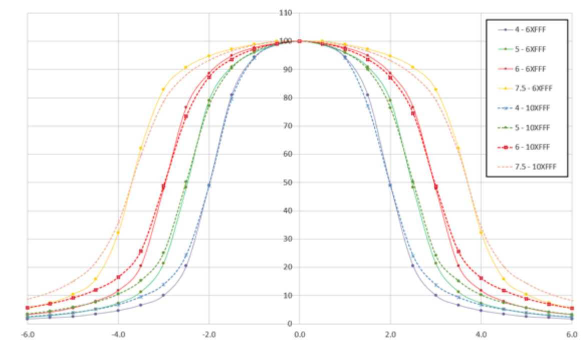


Figure 1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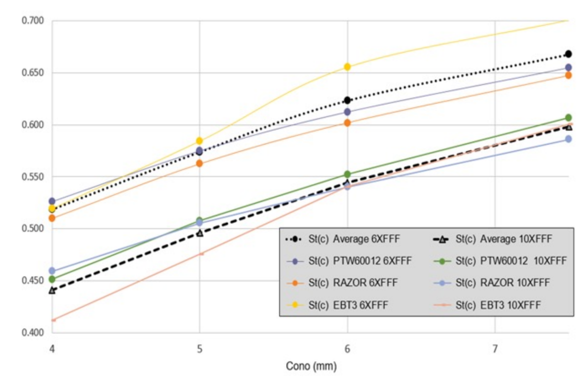
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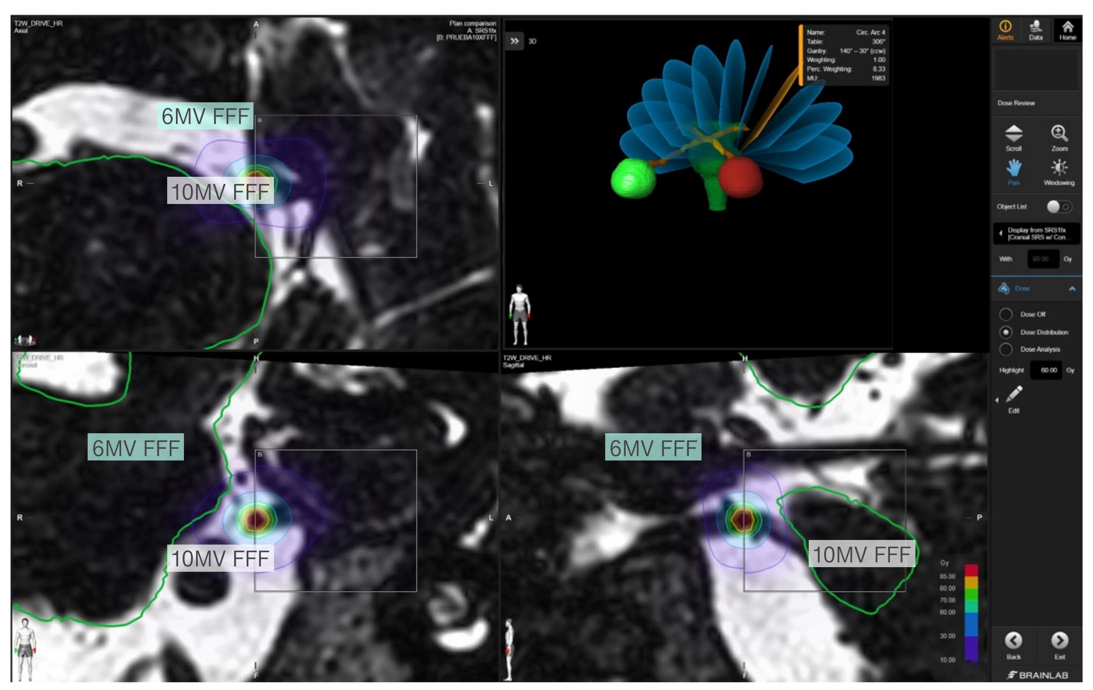

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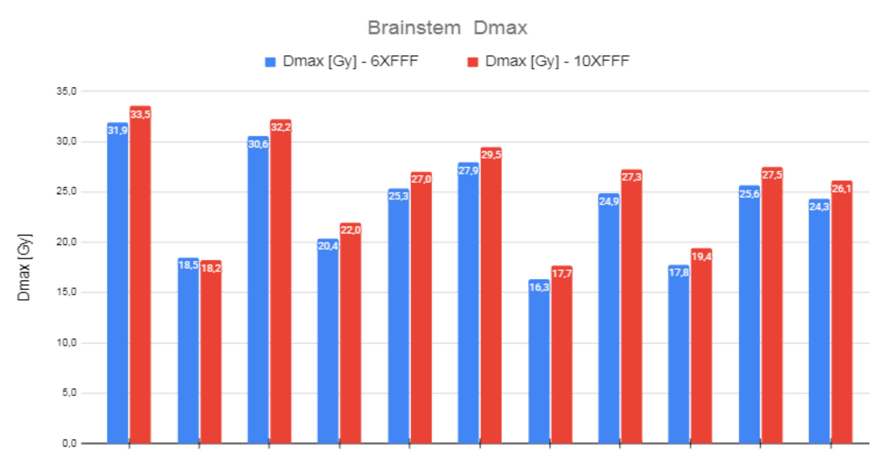

Table 1

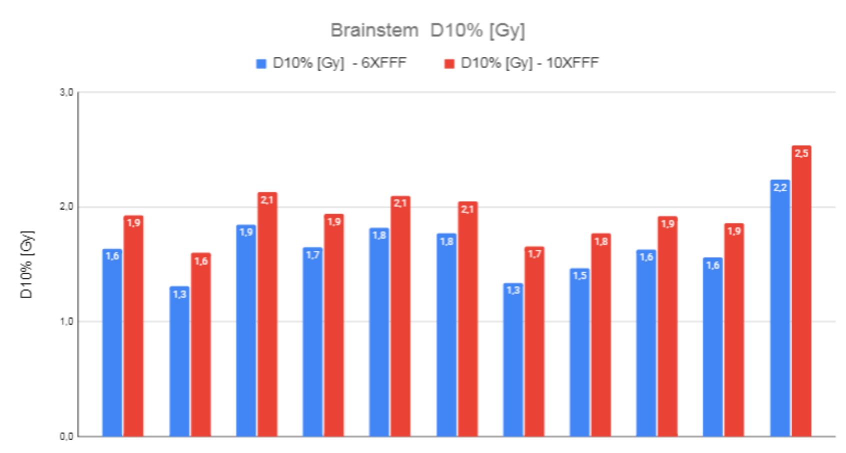

Table 2

Conclusion

10 MV-FFF plans reduce the treatment delivery time with a slight increment of dose to the brainstem in TN SRS. A position shift of the isocenter position, less than 0.3 mm could be required to have the 6 MV FFF plans brainstem dose, however this shift could be not necessary due the fulfillment of plan dose volume constraint. Treatment time reduction should be analyzed with a radiation oncologist if there is any dose-related effect.