

Improvements in Beam Geometry and Treatment Planning for Trigeminal Neuralgia with ZAP-X Conformal Table Insert over Legacy Flat Table

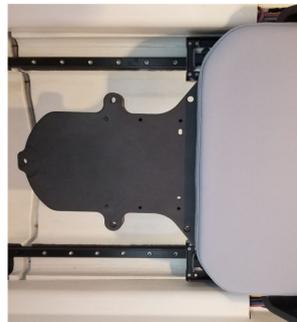
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Background

The ZAP-X Conformal Table purports a 15-25% increase in solid angle available for beams that were previously inaccessible due to potential for collision of the couch with the internal components of the ZAP-X delivery system. We present the plan and dosimetric improvements observed following the installation of the upgraded Conformal Table Insert with regard to treatment of Trigeminal Neuralgia patients on the ZAP-X platform.

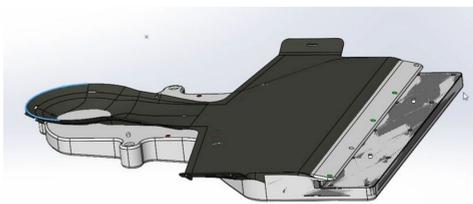
The ZAP-X Conformal Table upgrade was performed at our site in August 2024.



Legacy Flat Table Insert

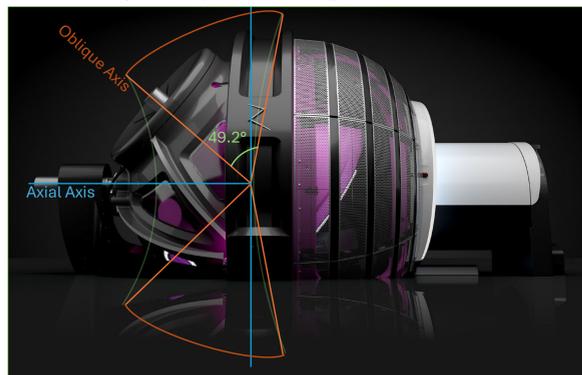


Orfit Conformal Table Insert



- We assess the improvement in solid angle for Trigeminal Neuralgia plans comparing patients treated prior to the couch upgrade to patients treated following the upgrade

ZAP-X beam geometry limits as implemented in version DP-1010

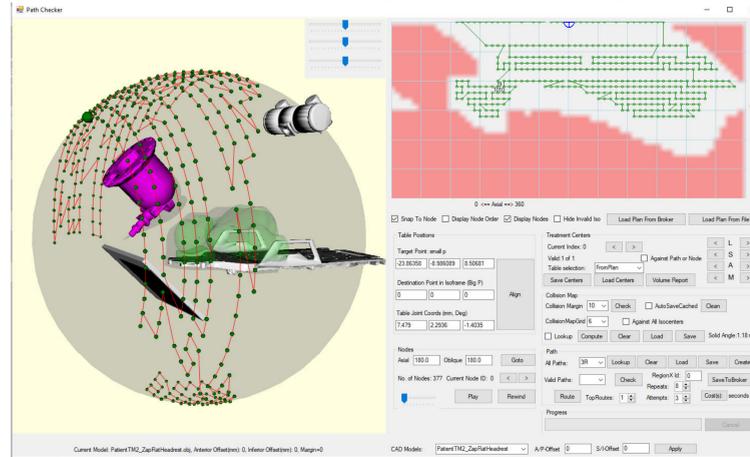


- Current maximum available solid angle is ~4.91 steradians.
- Inferior limit of Oblique Axis to be extended in future software versions.

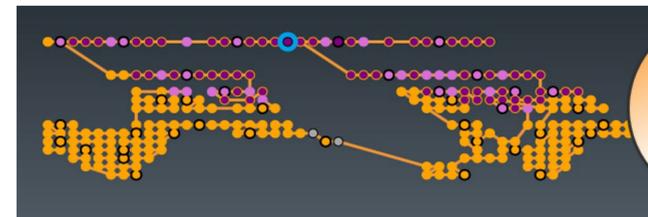
Methodology

- 3 Trigeminal Neuralgia (TN) patients were treated on the Legacy Flat Table. Since the Conformal Table upgrade, 21 TN patients have been treated.
- ZAP-X Treatment Planning software generates a planningbeamset.json file for a patient's treatment plan that contains the gantry nodes available after removal of beams that violate the collision model.
- ZAP-X Path Checker software will render this file and generate an estimate of the remaining Solid Angle for the node set.

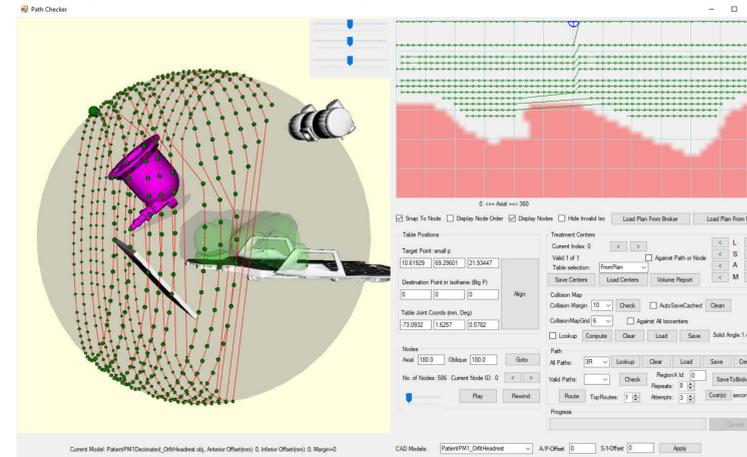
Example available node set for TN plan on Flat Table (Node path 12):



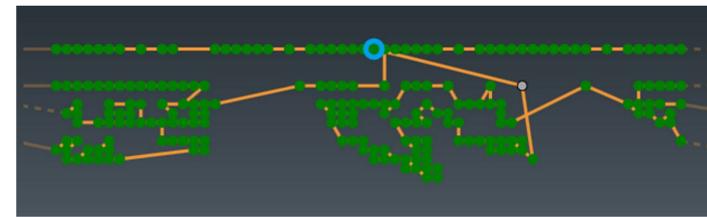
Treatment node set displaying nodes kept by treatment planning optimizer (261 beams utilized of 377 available nodes):



Example available node set for TN plan on Conformal Table (Node path 12):



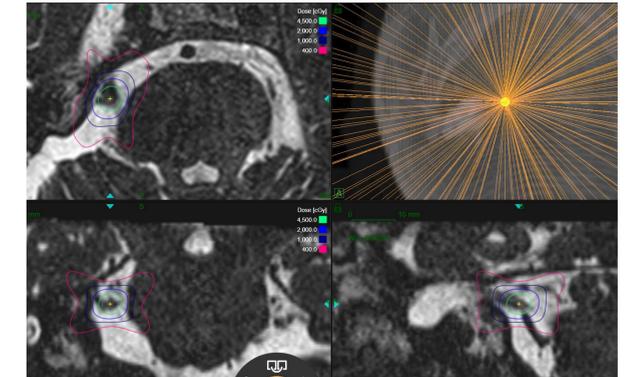
Treatment node set displaying nodes kept by treatment planning optimizer (210 beams utilized of 586 available nodes):



- When optimizing, we implement constraints to restrict beams from entering through the eyes which results in a slightly diminished solid angle for a treatment plan.

Discussion

- The Conformal Table provides access to most of the currently available solid angle. The current collision model is conservative near the shoulders such that beam nodes in the left and right lateral region are unavailable. The full posterior region of beam nodes is now available.
- The improved beam geometry has also been seen to reduce the volume of the 10Gy and 4Gy isodoses compared to plans using the Legacy Flat Table.
- Generally, fewer beams and a lower density node path can produce equivalent/improved plan quality for patients on the Conformal Table compared to the Legacy Flat Table.
- Our isocenter placement methodology is place isocenter such that the 20Gy line abuts the brainstem. A 4mm collimator is used and the plan is normalized to 90Gy maximum point dose. A 0.5mm dose grid is used for calculations.



- Low dose volumes are comparable to published Gamma Knife data, recognizing that the Gamma Knife prescribed to 80Gy maximum.¹

Measurement	Mean ± SD	
	Gamma Knife	
at 40 Gy (mm ³)	95.6 ± 2.6	
at 20 Gy (mm ³)	274.0 ± 11.4	
at 10 Gy (cm ²)	0.71 ± 0.04	
at 4 Gy (cm ²)	3.3 ± 0.3	

- Published maximum brainstem dose tolerance point dose of 29.5Gy² is easily respected on the ZAP-X platform.
- Our results compare favorably with published safe brainstem 0.1cc and 0.5cc doses (14.1Gy and 7.4Gy) achievable on Cyberknife.³

Analysis

	# Beams	Total MU	TPS estimated Delivery Time	Brainstem Max Point Dose (cGy)	Brainstem 0.03cc Max Dose (cGy)	Brainstem 0.1cc Max Dose (cGy)	Brainstem 0.5cc Max Dose (cGy)	V45Gy (cc)	V20Gy (cc)	V10Gy (cc)	V4Gy (cc)	Solid Angle (steradians)
Legacy Flat Table												
Average	253	22600.73	0:39:21	3258.93	1689.67	1061.33	517	0.07	0.32	0.96	4.41	4.304
Std Dev	17.44	606.03	0:01:47	903.45	452.87	194.36	56.56	0.01	0.04	0.12	0.79	0.65
Conformal Table												
Average	229	23136.62	0:39:47	2574.11	1405.29	943.29	485.43	0.08	0.32	0.91	4.12	4.727
Std Dev	22.85	664.27	0:01:04	609.56	208.68	106.06	41.46	0.00	0.01	0.05	0.44	0.11

References

- Descovich M, Sneed PK, Barbaro NM, McDermott MW, Chuang CF, Barani JJ, Nakamura JL, Ljun M. A dosimetric comparison between Gamma Knife and CyberKnife treatment plans for trigeminal neuralgia. J Neurosurg. 2010 Dec;113 Suppl:199-206. PMID: 21222296.
- Wamick RE, Paddick I, Mathieu D, Adam E, Iorio-Morin C, Leduc W, Hamel A, Johnson SE, Bydon M, Niranjan A, Lunsford LD, Wei Z, Waite K, Jose S, Peker S, Samanci MY, Tek E, Mantziaris G, Papis S, Sheehan JP, Tripathi M, Kumar N, Alzate JD, Bernstein K, Ahorukomeye P, Kshetry VR, Speckter H, Hernandez W, Urgosik D, Lisčák R, Yang AI, Lee JYK, Patel S, Kusyk DM, Shepard MJ, Kondziolka D. The relevance of biologically effective dose for pain relief and sensory dysfunction after Gamma Knife radiosurgery for trigeminal neuralgia: an 871-patient multicenter study. J Neurosurg. 2024 Feb 16;141(2):461-473. doi: 10.3171/2023.12.JNS231569. PMID: 38364220.
- Krishna C, Monroe, Ronald L, Hammers, Olivier C, Blasi, Richard C, Mallory, Alan T, Monroe, Single Fraction Radiosurgical Tolerance of Brainstem, Trigeminal Nerve, and Meckel's Cave for Facial Numbness, Practical Radiation Oncology, 2024, In Press.