



NAVIGATION-GUIDED TRANSNASAL ENDOSCOPIC DELINEATION OF THE POSTERIOR MARGIN FOR MAXILLARY SINUS CANCERS: A PRECLINICAL STUDY

Correspondence to: Stefano Tabonii, MD;
 University of Padua (Italy); email:
 stefanotaboni@gmail.com



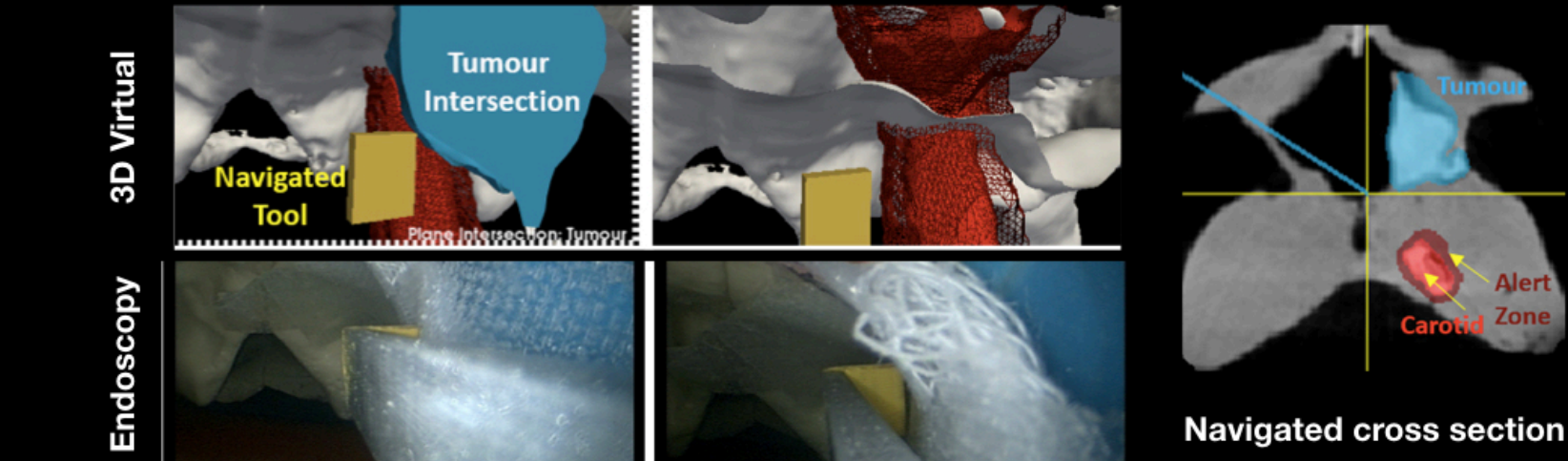
Stefano Taboni^(1,2,4,5), Michael Daly⁽⁴⁾, Marco Ferrari^(1,3,4), Harley Chan⁽⁴⁾, Donovan Eu^(4,5), Tommaso Gualtieri^(3,4), Ashok Jethwa⁽⁵⁾, Axel Sahovaler^(4,5), Andrew Sewell⁽⁵⁾, Wael Hasan⁽⁵⁾, Ilyes Berania⁽⁵⁾, Jimmy Qiu⁽⁴⁾, John de Almeida⁽⁵⁾, Piero Nicolai⁽¹⁾, Ralph Gilbert⁽⁵⁾, Jonathan Irish⁽⁵⁾

1. Section of Otorhinolaryngology – Head and Neck Surgery, Department of Neurosciences, University of Padua, Padua, Italy
2. Artificial Intelligence in Medicine and Innovation in Clinical Research and Methodology (PhD program), University of Brescia, Brescia, Italy
3. Unit of Otorhinolaryngology – Head and Neck Surgery, Department of Medical and Surgical Specialties, Radiological Sciences and Public Health; University of Brescia, Brescia, Italy
4. Guided Therapeutics (GTx) Program, Techna Institute, University Health Network, Toronto, Ontario, Canada, University of Toronto, Toronto, Canada
5. Department of Otolaryngology – Head and Neck Surgery/Surgical Oncology, Princess Margaret Cancer Centre/University Health Network, University of Toronto, Toronto, Canada



Background & Aim

Resection of advanced maxillary sinus cancers can be challenging due to the anatomical relationships with the surrounding neurovascular structures. Transnasal endoscopy can effectively aid the delineation of the posterior margin of resection. Implementation of endoscopy with three-dimensional (3D) navigation may represent a step forward. This study was aimed to demonstrate and quantify the benefits of 3Dnavigation-endoscopy-guided delineation of the posterior margin during maxillectomies.



Material and methods

Four maxillary tumors models with critical posterior extension were created in 4 artificial skulls (Sawbones®). The ipsilateral internal carotid arteries (ICA) were 3D printed, painted with red dye mixed with iodine, and positioned into models. Three-D images were acquired with cone-beam computed tomography and tumor and carotid were contoured with ITK-SNAP®. Four head and neck surgeons with variable experience were recruited for the simulations. During the simulations, surgeons were asked to delineate transnasally the posterior margin of resection avoiding the ICA while establishing an adequate distance of the virtual cut with respect to the tumor surface. Surgeons could use pointers with different angulations (0°, 30°, 45°, 60°, and 90°) and 2 scopes (0° and 45°). Three simulations were performed: 1) unguided: based on pre-simulation study of cross-sectional imaging; 2) tumor-guided: guided by real-time tool tracking with 3D tumor and carotid rendering; 3) carotid-guided: tumor-guided with a 2-mm alert cloud surrounding the carotid. Analysis of cutting planes was performed by isolating a 30x11mm area starting from the pointer tip. Distances of planes from carotid and tumor were classified as follows and points of the plane were classified accordingly: “red”: through carotid; “orange1”: <2 mm from carotid and intratumoral; “orange2”: <2 mm from carotid and <5 mm from tumor; “orange3”: < 2 mm from carotid and 5-10 mm from tumor; “orange4”: <2 mm from carotid and >10 mm from tumor; “yellow1”: >2 mm from carotid and intratumoral; “yellow2”: >2 mm from carotid and <5 mm from tumor; “green”: >2 mm from carotid and 5-10 mm from tumor; “blue”: >2 mm from carotid and >10 mm from tumor. The three techniques (unguided, tumour-guided and carotidguided) were compared.

Results

Real-time 3D navigation virtual endoscopy for the transnasal delineation of the posterior margin in maxillary tumor models significantly improved the rate of adequate planes of dissection and reduced the carotid damage. “Green” cuts were 50.0% in the unguided setting vs 60.6% and 63.5% in the tumor- and carotid-guided, respectively. “Red” cuts were 5.5% in the unguided setting vs 0.9% and 1.1% in the tumor- and carotidguided, respectively. “Yellow+Orange” cuts were 34.0% in the unguided setting vs 30.2% and 29.5% in the tumor- and carotid-guided, respectively. “Blue” cuts were 10.5% in the unguided setting vs 8.3% and 5.8% in the tumor- and carotid-guided, respectively.

	Unguided	Tumor-G	Carotid-G	Carotid&Tumor Distance Category
Red	5.5%	0.9%	1.1%	Into Carotid
Orange1	0.0%	0.0%	0.0%	<2 mm Carotid, into Tumor
Orange2	0.4%	0.1%	0.2%	<2 mm Carotid, <5 mm Tumor
Orange3	3.9%	2.5%	2.5%	<2 mm Carotid, 5-10 mm Tumor
Orange4	1.3%	0.1%	0.2%	<2 mm Carotid, >10 mm Tumor
Yellow1	5.1%	0.6%	0.2%	>2 mm Carotid, into Tumor
Yellow2	23.3%	26.9%	26.4%	>2 mm Carotid, <5 mm Tumor
Green	50.0%	60.6%	63.5%	>2 mm Carotid, 5-10 mm Tumor
Blue	10.5%	8.3%	5.8%	>2 mm Carotid, >10 mm Tumor

Conclusions

This preclinical study has demonstrated that 3D-navigation-endoscopyguidance provides a substantial improvement of the posterior margin delineation in terms of safety and oncological adequacy. Translation into the clinical setting, with a meticulous assessment of oncological outcomes, will be the proposed next step.

Example of the analysis of posterior margin delineation: each point of the isolated area was classified according to the established color code

