High Resolution MRI of the Pterygopalatine Ganglion
Start Time: 9/18/2017, 1:30 PM

Author(s)
Dean T. Jeffery, MD
Neuroradiology Fellow
Johns Hopkins University, University of Alberta

Role: Presenting Author

Nafi Aygun, MD
Associate Professor
Johns Hopkins Hospital and University

Role: Author

Caroline Jeffery, MD
Assistant Professor
University of Alberta

Role: Author

Ari Blitz, MD
Assistant Professor
Johns Hopkins University and Hospital

Abstract Details
Purpose: The pterygopalatine ganglion (PPG) is an important neurologic crossroad within the pterygopalatine fossa (PPF), synapsing with parasympathetic fibres and transmitting without synapsing with sympathetic and sensory fibres. It has been implicated in several headache and neuralgia syndromes, such as cluster headache and Sluder’s Neuralgia. We provide the first, to our knowledge, literature description of in-vivo high resolution MRI appearance of the PPG.

Materials/Methods: A large database of high-resolution skull base imaging studies performed between 2011 and 2014 was consecutively queried. Patients with known PPF, trigeminal or vidian nerve pathology were excluded. A total of 20 patients (40 PPGs) were identified. Multi-planar reconstruction of pre and post-gadolinium 6mm isotropic CISS imaging performed at 3T was available for all cases. The visualized PPG ganglion was measured in 3-dimensions, and characterized in terms of its enhancement and location in relation to relevant anatomic structures such as the sphenopalatine foramen (SPF) and sphenopalatine artery (SPA).

Results: The PPG was readily identified in 32/40 cases, identified with some difficulty in 6/40, and not well seen in 2/40. Average size of the PPG ganglion was 1.8x4.9x6.9mm (±0.4x1.0x1.5mm). The PPG extended frankly medial to the SPF in 9/40 cases and was at or extending slightly medial to the SPF in 22/40 cases. The SPA passed directly anterior to the PPG in the majority (33/40) cases and was thought to abut the PPG in
16/40 cases. The PPG enhanced in 100% of cases.

Conclusions: We report the first systematic analysis and MRI visualization of the PPG in-vivo. This has significant implications for imaging of atypical facial pain syndromes and pre-operative localization of the PPG.
Prognostic implications of imaging characteristics in skull base chordomas

Start Time: 9/18/2017, 1:38 PM

Author(s)
Eaton Lin, MD
Assistant Professor
Weill Cornell Medicine

Role: Presenting Author
C. Douglas Phillips, MD FACR
Professor of Radiology, Director of Head and Neck Imaging
Weill Cornell Medicine

Abstract Details
Purpose: The aim of this study was to assess the prognostic implications of imaging characteristics in skull base chordomas.

Materials and Methods: Medical records were retrospectively reviewed for 22 patients with pathologically confirmed skull base chordomas. Clinical data were recorded, including degree of surgical resection, presence or absence of radiation therapy, and time to progression/recurrence of tumor or time without progression/recurrence of tumor following initial treatment. Imaging was reviewed, with presence or absence of enhancement noted. Tumor-to-brainstem signal intensity ratios on T2 (RT2), pre-contrast T1 (Rpre), and post-contrast T1 (Rpost) spin-echo sequences were also calculated. Statistical analysis was then performed to assess for correlations between imaging characteristics and tumor progression/recurrence.

Results: Progression/recurrence of skull base chordomas was seen following surgical resection in 11 of 14 (78.6%) patients with enhancing tumors, and in 0 of 8 patients with non-enhancing tumors. There was a statistically significant correlation between skull base chordoma enhancement and subsequent tumor progression/recurrence (p < 0.001) which remained significant after controlling for differences in treatment strategy (p < 0.001). There was also a statistically significant correlation between the intensity of postcontrast T1 signal (as measured by Rpost) and recurrence/progression (p = 0.02). While T2 signal intensity was higher in patients without tumor progression (median RT2 = 2.27) than those with progression (median RT2 = 1.78), this association was not statistically significant (p = 0.12).

Conclusion: Enhancement of skull base chordomas is a risk factor for tumor progression or recurrence following surgical resection.
Exploratory Study for Identifying Predictors for Treatment Response of Head and Neck Cancers on CT Using Computerized Analysis.
Start Time: 9/18/2017, 1:46 PM

Author(s)
Sean Woolen, MD, MS
Resident
University of Michigan

Role: Presenting Author
Lubomir Hadjiiski, PhD
Professor, Radiology
University of Michigan

Role: Author
Kenny Cha, MSc
Graduate Student
University of Michigan

Role: Author
Heang-Ping Chan, PhD
Professor, Radiology
University of Michigan

Role: Author
Francis Worden, MD
Professor, Medical Oncology
University of Michigan

Role: Author
Paul Swiecicki, MD
Hematology Oncology
University of Michigan

Role: Author
Ashok Srinivasan, MBBS
Associate Professor, Director Neuroradiology
University of Michigan
Abstract Details

Purpose: AT-101 is an oral chemotherapeutic agent that induces apoptosis and may be beneficial in laryngeal cancer patients treated with organ preservation therapy. The objective of our study was to investigate the feasibility of using radiomic and perfusion features as predictors of tumor response to AT-101.

Method and Materials: Retrospective analysis of pre and post therapy CT neck scans was performed in 19 patients diagnosed with laryngeal cancer in this IRB approved study. Contouring of the tumors was performed by the computer and tumor features were generated on an internally developed/validated computer aided detection (CAD) system. The system performs 3D segmentation on the basis of a level-set model using an approximate bounding box for the lesion of interest. Twenty six radiomic features including morphological and gray-level features, were extracted from the computer. Five perfusion features including permeability surface area product (PS), blood flow (flow), blood volume (BV), mean transit time (MTT), and time-to-maximum (Tmax) were extracted from the computer. Post-treatment responses were obtained after one cycle of AT-101 chemotherapy from laryngoscopic exam. A positive response was recorded when there was at least 50% reduction in tumor volume. We performed a two-loop leave one out feature selection using linear discriminant analysis classifier for two radiomics features. We then took one feature from radiomic and perfusion (2 total), and built a classifier to do a leave-one-out cross-validation. Receiver operator curves and standard deviation were generated.

Results: All 19 lesions examined were primary laryngeal cancers. Out of the 19 patients, there were 7 non-responders (37%) and 12 responders (63%). Selecting two radiomics features alone had an area under the curve (AUC) measuring 0.83 +/- 0.09. Out of all of the features, the best radiomic and perfusion features were the change in contrast enhancement and PS. The best radiomic and perfusion combined improved the AUC to 0.84 +/- 0.9.

Conclusion: Predicting treatment response to chemotherapy is an important tool for head and neck cancer management. Our pilot study indicate that radiomic features are good predictors for treatment response with AT-101. The combination of radiomic and perfusion minimally improved prediction. Our next step is expand our data set with additional available patients.
Figure 1. CT and perfusion sections of laryngeal carcinoma on pretreatment images. Axial sections show the grey scale image (A) and outlines for the following: computer (B) and permeability surface area product (C).

Figure 2. CT and perfusion sections of laryngeal carcinoma on posttreatment images. Axial sections show the grey scale image (A) and outlines for the following: computer (B) and permeability surface area product (C).

Table 1. Area under the curve +/- standard deviation for radiomic and radiomic + perfusion.

<table>
<thead>
<tr>
<th>Features</th>
<th>Radiomics Only</th>
<th>Radiomics + Perfusion (PS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUC ± SD</td>
<td>0.83 ± 0.09</td>
<td>0.84 ± 0.09</td>
</tr>
</tbody>
</table>

Figure 3. Receiver operator curves for radiomics and perfusion + radiomics for 19 pretreatment and posttreatment tumors.
Dual Energy CT Iodine Quantification and Spectral Analysis in Squamous Cell Carcinoma of the Head and Neck
Start Time: 9/18/2017, 1:54 PM

Author(s)
Alexandra M. Foust, D.O.
Radiology resident
The Ohio State University Wexner Medical Center

Role: Presenting Author

Rukya Ali, M.D.
Radiology Resident
The Ohio State University Wexner Medical Center

Role: Author

Xuan V. Nguyen, M.D., PhD.
Attending Neuroradiologist
The Ohio State University Wexner Medical Center

Role: Author

Amit Agrawal, M.D.
Attending Otolaryngologist
The Ohio State University Wexner Medical Center

Role: Author

Joici Job, M.D.
Attending Neuroradiologist
The Ohio State University Wexner Medical Center

Role: Author

Eric Bourekas, M.D.
Attending Neuroradiologist
The Ohio State University Wexner Medical Center

Role: Author

Daniel Boulter, M.D.
Attending Neuroradiologist
The Ohio State University Wexner Medical Center
Abstract Details
Purpose:
Even a single lymph node metastasis in squamous cell carcinoma of the head and neck (HNSCC) is associated with up to 50% reduction in 5-year survival. Traditional CT imaging criteria for nodal metastasis such as size, shape, and/or internal necrosis are frequently unreliable with reported sensitivities as low as 52%. Dual energy CT (DECT) allows for improved discrimination and quantification of iodinated contrast, which may improve diagnostic performance for nodal metastases. We compared DECT derived quantitative iodine values and spectral attenuation curves in the primary lesion, metastatic lymph nodes, and non-metastatic lymph nodes in patients with newly diagnosed squamous cell carcinoma of the head and neck.

Materials and Method:
13 patients with newly diagnosed primary HNSCC and at least one metastatic lymph node underwent contrast enhanced DECT of the neck. 19 metastatic nodes and 26 non-metastatic nodes were retrospectively identified. Dual energy CT derived iodine content (mg/mL) measurements were obtained using circular regions of interest (ROI) within metastatic nodes, non-metastatic nodes, and the primary tumor if visible. Monoenergetic attenuation values at 40 keV and 100 keV were also obtained from circular ROI in the same locations. Arterial and venous iodine content values were obtained with circular ROIs placed over the jugular vein and common carotid artery. T-tests and Pearson’s correlation coefficient were used for data analysis.

Results:
Iodine content (mg/dL) was significantly lower in metastatic lymph nodes (1.12+0.54) compared with non-metastatic lymph nodes (1.66+0.53) via paired T-test, p = 0.006. The ratio of nodal iodine content to primary neoplasm was also significantly lower for metastatic nodes (0.89+0.45) compared to non-metastatic nodes (1.32+0.68) via paired T-test, p = 0.02. An ROC curve was generated revealing that at a threshold nodal iodine content value < 1.6 mg/dL there was a sensitivity of 95% and a specificity of 50%. The area under the ROC curve (AUC) was 0.75, 95% confidence interval: 0.59-0.86, p = 0.001. Iodine spectral attenuation curve slope was also significantly lower in metastatic nodes (1.38+0.81) compared with non-metastatic nodes (2.11+0.64) via paired T-test, p < 0.001. The ratio of nodal spectral attenuation slope to primary neoplasm spectral attenuation slope was significantly lower in metastatic nodes (0.93+0.52) compared to control nodes (1.42+0.55) via paired T-test, p = 0.002. A ROC curve for spectral attenuation slope revealed that at a slope of < 1.37 there is an optimized sensitivity of 63% and specificity of 89%. The AUC was 0.78, 95% CI: 0.63-0.89, p = 0.0002. Pearson’s correlation coefficient showed no correlation between nodal iodine content and the ratio of jugular to common carotid iodine content (R= 0.05), p= 0.87.

Conclusion:
Dual energy CT derived quantitative iodine data and spectral attenuation curves may improve the diagnostic accuracy of CT for nodal metastasis in patients with squamous cell carcinoma of the head and neck.
Abstract Details
Purpose: There is a rich amount of quantitative information in spectral datasets generated from dual energy CT (DECT) scans. In this study, we compared the performance of texture analysis performed on multi-energy datasets to texture analysis of virtual monochromatic images (VMIs) at 65 keV only for classification of the two most common benign parotid neoplasms.

Materials & Methods: A retrospective single center study was performed. A total of 42 patients with pathologically proven Warthin tumor (n = 25) or pleomorphic adenoma (n = 17) were evaluated. All patients had undergone a DECT scan using a 64-slice fast kVp switching scanner (GE Discovery CT750HD; GE Healthcare, Milwaukee, WI) that included a contrast-enhanced phase 65s after injection of 80 mL of Iopamidol (Isovue 300®, Bracco Diagnostics Inc.) Texture analysis was performed using a commercial software (TexRAD Ltd, Cambridge, United Kingdom). For each case, a region of interest (ROI) was drawn around the tumor on its largest cross-sectional area not obscured by artifact using manual segmentation on axial images. Texture feature extraction was performed on VMIs ranging from 40 to 140 keV in 5 keV increments for multi-energy analysis or 65 keV VMIs only, typically considered equivalent to a standard single energy CT acquisition. Random Forests (RF) models were constructed using various histogram-based texture features for outcome prediction with internal cross-validation in addition to use of separate randomly selected training
(70%) and testing (30%) sets. Accuracy (Acc), Sensitivity (Sens), specificity (Spec), positive predictive value (PPV), and negative predictive value (NPV) were determined for tumor classification.

Results: Using multi-energy texture analysis, tumor classification could be performed with Acc, Sens, Spec, PPV, and NPV of 75%, 71%, 80%, 83%, and 67%, respectively. On the other hand, single energy (65 keV) texture analysis had a much lower accuracy, with an Acc, Sens, Spec, PPV, and NPV of 58%, 57%, 60%, 67%, and 50%, respectively.

Conclusions: Texture analysis can be used to classify pleomorphic adenomas and Warthin tumors with relatively good accuracy, and multi-energy texture analysis has superior performance compared to analysis of single energy VMIs at 65 keV.
Is Non-Enhanced CT a Useful Tool for the Characterization of incidentally Detected FDG-avid Nodules on FDG PET/CT.
Start Time: 9/18/2017, 2:10 PM

Author(s)
Manohar Kuruva, MD
Resident
UAMS RADIOLOGY

Role: Presenting Author

James McDonald, MD
Chair
UAMS Radiology

Role: Author

Donald Bodenner, MD
Professor
Dept of Endocrinology UAMS

Role: Author

Brendan Stack, Jr., MD
Professor
UAMS Otolaryngology

Role: Author

Fitzgerald Ryan, MD
Assistant professor
UAMS Radiology

Abstract Details
Purpose:
This retrospective study was carried out to assess the utility of non-contrast computed tomography (NCCT) in predicting the nature of thyroid nodules in patients with incidentally diagnosed F-18 fluoro-deoxy glucose (FDG) positive nodules/focal uptake in the thyroid gland.

Materials and Methods:
We performed a retrospective review of 56 patients who had incidentally detected focal FDG uptake in thyroid gland and had histopathological diagnosis of the abnormality. Assessed NCCT parameters included the presence or absence of a distinct nodule, mean attenuation of the nodule in HU, nodule margins, presence or absence of macrocalcifications, and anteroposterior diameter/transverse diameter ratio (AP/T ratio). Chi-square test was used to assess the distribution of categorical variables in benign and malignant nodules.
Student t test was used for quantitative variables.

Results:
29 females and 27 males were included in the study (age 19-84 years, mean 64 years). Two of the 56 patients with intra-thyroidal FDG avidity had no distinct CT abnormality and were excluded from the final analysis. Final diagnosis of malignancy was made in 15/54 (27%) patients. No significant difference was found between attenuation values of benign and malignant nodules (48.8 vs 50.3 HU p=0.85) and AP/T ratios (1.18 vs 1.16 p=0.76). Nodule margins were not significantly different between benign and malignant nodules (50% vs 33% p=0.5). Macrocalkifications were encountered in 6/39 benign nodules and none in 15 malignant nodules (15% vs 0%). Standardized uptake values were significantly different between malignant and benign nodules (6.0 vs 3.2 p=0.03).

Conclusions:
A concordant NCCT abnormality is present in 54/56 (96%) of incidentally discovered FDG avid nodules. Macrocalkifications are the only specific feature associated with benignity of incidentally detected focal FDG avid nodules although with a low sensitivity of 15% and a negative predictive value of 82%. Other features such as mean attenuation value, nodule margins, and AP/T ratio of nodules do not have significant predictive value in separating benign from malignant nodules. Further evaluation of ultrasound may be needed in all patients who do not have benign calcifications on NCCT.
Cerebral blood flow characterization of skull base paragangliomas with arterial spin labeling imaging.

Start Time: 9/18/2017, 2:18 PM

Author(s)
Kevin A. Hsu, MD
Fellow
Department of Neuroimaging and Neurointervention, Stanford Hospital and Clinics

Role: Presenting Author

Mrudula Penta, MD
Clinical Instructor
Department of Neuroimaging and Neurointervention, Stanford Hospital and Clinics

Role: Author

Michael Iv, MD
Clinical Assistant Professor
Department of Neuroimaging and Neurointervention, Stanford Hospital and Clinics

Role: Author

Nancy Fischbein, MD
Professor, Department of Neuroradiology
Stanford Hospital

Role: Author

Greg Zaharchuk, MD, PhD
Associate Professor
Department of Neuroimaging and Neurointervention, Stanford Hospital and Clinics

Abstract Details

Purpose
Cerebral blood flow evaluation of various neoplastic and vascular lesions of the skull base with Arterial Spin Labeling (ASL) technique has been shown to be useful. The purpose of this study is to investigate and describe the characteristics of ASL perfusion of skull base paragangliomas in both the pre- and post-treatment settings.
Materials & Methods
In this IRB-approved retrospective study at a single academic institution, we reviewed PACS for patients with skull base paraganglioma diagnosed on MRI between 2008 and 2017. All MRI studies consisted of T2-weighted, post-gadolinium T1-weighted, and ASL images. The diagnosis of paraganglioma was made by characteristic imaging and clinical features as well as histopathology in available cases. Clinical information obtained from the electronic medical record, including pretreatment and posttreatment histories, was recorded. Tumor size was obtained by measuring the greatest orthogonal dimension of the tumor on the axial post-gadolinium T1-weighted images. Two fellowship-trained neuroradiologists drew a region of interest (ROI) around each tumor on post-processed ASL images to obtain the tumor cerebral blood flow (CBFT) value. Another ROI was drawn in the normal contralateral gray matter (CBFC) to obtain a normalized CBF ratio (CBFT/CBFC). Descriptive statistics of CBF and Pearson correlation between tumor size and CBF were calculated. Inter-rated reliability was analyzed with a Bland-Altman Plot.

Results
20 patients with a total of 30 MRIs were included in the study. Of the 20 patients, 9 had pre-treatment and 14 had post-treatment imaging (13 post-CyberKnife, 1 partial resection). 2 patients had both pre-treatment and post-treatment imaging. Of the post-treatment group, 3 had additional follow-up imaging. Average size of the lesion for the entire cohort, pretreatment group, and posttreatment group was 258±228, 315±288, and 208±158 mm^2. Mean and standard deviation of absolute CBFT of the entire cohort, pretreatment group, and posttreatment group was 438±205, 385±238, and 190±67 ml/100 g/min, respectively. CBFT/CBFC with standard deviation of the entire cohort, pretreatment group, and posttreatment group was 6.74±2.93, 6.07±3.37, and 7.23±2.44, respectively. Tumor size was moderately correlated with CBFT/CBFC (R = 0.47, p < 0.05). Of the post-treatment group with follow-up MRI, CBFT/CBFC values were decreased in all cases, by 10%, 16%, and 46% with mean follow up of 8.2±2.3 months. There was good inter-rater reliability.

Conclusions
High CBF as measured with ASL perfusion is a prominent feature of skull base paragangliomas, and this decreases between the pre-treatment and post-treatment groups. Our results suggest the utility of ASL in the evaluation of skull base paragangliomas—aiding in diagnosis, determination of extent, and assessment of treatment response.
Abstract Details

Purpose:
The purpose of this retrospective study is to create quantitative metrics for the evaluation of extraocular muscle (EOM) positioning, namely the lateral rectus (LR). Sagging eye syndrome is a senile connective tissue (CT) disorder in which laxity of the lateral rectus-superior rectus CT band inferiorly displaces the LR pulley. Pulley displacement misdirects LR muscular forces and results in strabismus and diplopia to distance. To date, methodology for quantitative analysis of EOM has not been described in the literature. Our study aims to describe quantitative metrics of LR positioning, establish a range of values that diagnoses SES on imaging, and establish an atlas of normal EOM positioning.

Materials/methods:
Our retrospective study composed of a group of two clinically diagnosed and non-surgically treated SES patients and a control group of 43 individuals without EOM or CT pathology by clinical and imaging criteria. Orbital MRI axial FIESTA sequences of all patients were reformatted on TeraRecon into the coronal oblique plane using the optic nerve as a central axis. At the level of mid-muscle belly, a single image was obtained and saved. On 3D Slicer, points were placed at the center of the optic nerve, the superior and inferior LR and medial rectus (MR) (to give a mid-belly point), and the superior and inferior orbital rim. Three angles were calculated: angle 1 is the angle of MR displacement from the optic nerve horizontal plane; angle 2 is the angle of LR displacement from the optic nerve horizontal plane; angle 3 is the angle between the LR and MR. A ratio was calculated comparing the distance from the superior orbit to the mid-muscle and the inferior orbit to the mid-muscle.

Results:
In the control group, mean and standard deviation of angle 1 is 13.3 +/- 8.5, angle 2 is 13.2 +/- 8.0, and angle 3 is 154.0 +/- 14.9. In patient A, angle 1 is 17.7, angle 2 is 22.4, and angle 3 is 157.5 with a z-score of 0.51, 1.2, and -0.9, respectively. In patient B, angle 1 is 5.3, angle 2 is 17.3, and angle 3 is 157.5 with a z-score of -0.9, 0.5, and 0.2, respectively. In the control group, the mean and standard deviation of the ratio is 1.0 +/- 0.2. In patient A, the ratio is 0.7 with a z-score of -1.1. In patient B, the ratio is 0.8 with a z score of -0.7. This preliminary analysis demonstrates that ratio is the most reliable metric followed by angle 2. Angles 1 and 3 are less reliable. Our current analysis is limited by our small SES sample size.

Conclusions:
Our methodology of quantifying EOM position aims to establish accurate and reproducible metrics for the evaluation of EOM positioning. Continuation of our preliminary analysis will define a range of diagnostic measurements for SES on initial orbital imaging. By establishing an atlas of normal EOM positioning, we hope our quantitative metrics can be expanded to evaluate a sundry of EOM disease entities.
Quantitative Measurements

Landmarks for 3D Slicer (Normal orbit)

Angles 1, 2, and 3 (Sagging eye syndrome orbit)

Ratio A:B (Sagging eye syndrome orbit)
3D Printed Anatomically Accurate Mandibular Fractures For Anatomic Visualization, Fracture Classification, and Pre-surgical Planning

Author(s)
Laura B. Eisenmenger, MD
Radiology Resident
University of Utah

Role: Presenting Author

Michael Bayona, MD
Radiology Resident
University of Utah

Role: Author

Erika Minoshima
Undergraduate Student
University of Utah

Role: Author

Phillip Lee, MD
Otolaryngology Resident
University of Utah

Role: Author

Aaron Prussin, MD
Otolaryngology Assistant Professor
University of Utah

Role: Author

Craig Johnson, MD
Neuroradiology Fellow
University of Utah

Role: Author

Justin Cramer, MD
Assistant Professor of Radiology
University of Nebraska
Abstract Details

Purpose: To generate an open source, downloadable library of 3D-printed, anatomically accurate models of complex mandibular fractures and dislocations with adjacent osseous structures to provide surgeons with additional visual and tactile information. These physical and virtual models can improve trainee and patient education and be used for preoperative simulation. This project also compares open source software and commercial solutions to interacting with virtual models in our 3D printing workflow. Image fusion of different modalities is compared across virtual reality, augmented reality, and stereoscopic display systems.

Materials & Methods: De-identified CT and CT angiogram of facial trauma cases to make 3D models of DICOM data. Materialise Mimics (Plymouth, MI, USA), TeraRecon (Foster City, CA, USA), and Slicer (Boston, MA, USA) were used to segment and create virtual models (Image 1). Next, fused filament fabrication (FFF) 3D-printer (Ultimaker 2+, Ultimaker 3, or Fusion3D) was used to create Poly lactic acid (PLA) or acrylonitrile butadiene styrene (ABS) models of complex mandibular fractures. The fractures and adjacent osseous structures were printed correlating with cross sectional imaging. We tested these with radiology residents, fellows, and consulting subspecialties. 3D-printed models were evaluated by two otolaryngologists to confirm anatomic fidelity to source images. Otolaryngologists evaluated the 3D mandibular fracture prints to assess for utility in patient education, assigning fracture classification, improving anatomic understanding of the fractures, pre-operative planning, and to determine which features of the models were the most helpful. We also compared open source software and commercial solutions to interacting with virtual models in our 3D printing workflow of complex mandibular fractures. We applied Google Cardboard, Oculus virtual reality system, and
stereoscopic pseudo holographic systems. Image fusion of different modalities was compared across these immersive display systems.

Results: Otolaryngologists confirmed the anatomic accuracy of the 3D prints compared to imaging. Otolaryngologist staff noted that 3D printed mandibular fracture models aided in trainee education, improved anatomic understanding of the lesion, and pre-operative planning. Neuro radiologists found that having virtual and physical examples of common fracture patterns allowed better training of radiology residents and fellows.

Conclusions: A 3D printed mandibular fracture model can be used for trainee and patient education, improved anatomic understanding and classification of the fractures, and pre-operative planning. Trainees and consultants find interaction with virtualized models aid understanding of anatomy, pathology, and treatment options. Future prospective research is needed to evaluate for improved patient outcomes and decreased operative time with the use of 3D-printed mandibular fractures simulators. A representative physical and virtual library of the AO CMF classification aids radiology education of complex head and neck trauma.