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传统影像组学与深度学习在口腔癌影像诊断中的性能对比分析

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摘　要

口腔癌的早期诊断对治疗口腔癌的意义重大。早期口腔癌治愈可能性最高，而中后期口腔癌治愈可能性较低。因此，提高口腔癌的早期诊断率有着举足轻重的作用。目前，传统影像组学与深度学习在口腔癌影像诊断中的作用逐渐升高，通过两者的辅助可以显著提高口腔癌的诊断率。本综述通过系统回顾相关研究，对比两者在口腔癌影像诊断中的性能，为临床依据实际需求对症下药，对流程精益求精，助力提高口腔癌诊断效率与精准度。

关键词

影像组学，深度学习，口腔癌，口腔鳞状细胞癌，曲线下面积

Comparison and Analysis of the Performance between Traditional Radiomics and Deep Learning in Imaging Diagnosis of Oral Cancer

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Abstract

Early diagnosis of oral cancer is of great significance in the treatment of oral cancer. Early oral

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cancer has the possibility of cure, while the mortality rate of oral cancer in the middle and late stages has risen sharply. Therefore, improving the early diagnosis rate of oral cancer plays a pivotal role. At present, the role of traditional radiomics and deep learning in the diagnosis of oral cancer imaging is gradually increasing, and the diagnosis rate of oral cancer can be significantly improved through the assistance of the two. This review systematically reviews relevant studies and compares the performance of the two in oral cancer imaging diagnosis, prescribes the right medicine for clinical clinical needs, strives for improvement in the process, and helps improve the efficiency and accuracy of oral cancer diagnosis.

Keywords

Traditional Radiomics, Deep Learning, Oral Cancer, Oral Squamous Cell Carcinoma, Area under the Curve (AUC)

1. 前言

口腔癌症是一种常见于口腔组织内的恶性肿瘤，死亡率高，对公众健康危害极大。口腔鳞状细胞癌(OSCC)是口腔癌症最常见的类型，在全球所有类型的癌症中排名第七[1]。口腔癌症已经发展成为新兴和中低收入国家最常见的恶性肿瘤之一，但如果及早发现并有效治疗口腔癌症，可以显著降低死亡率[2]。

但临床医生光凭借肉眼识别口腔癌症，是无法看到口腔细微病变变化的。这使得一些患者错过了最佳的治疗时机。

在传统影像组学和深度学习的应用前，临床医生如若要进一步确认患者情况，只能通过活检，但其耗时过长，依靠医师的经验比重大。

所以，传统影像组学和深度学习技术的应用和突破，关系到此病症的诊断。

本综述纳入 50 篇文献，对比分析了传统影像组学和深度学习在口腔癌影像诊断中的核心指标等。

2. 材料与方法

2.1. 文献纳入方法

本综述纳入 2015~2024 年发表的口腔癌影像诊断的相关文献。该搜索是使用三个不同的外文数据库 PubMed、Web of Science 和 Medline 以及两个中文数据库万方、知网。相关文献需同时满足研究对象为经病理证实的口腔癌患者；明确采用传统影像组学或深度学习方法进行诊断或分析；提供相应的诊断性能指标；研究类型为原始论著，排除综述等。

2.2. 数据提取及分析方法

从纳入文献中提取以下信息：

1) 基本信息：作者、年份、样本量、疾病亚型；
2) 技术参数：影像模态、模型算法；
3) 性能指标：AUC、灵敏度、特异性、准确率等；
4) 适用场景：诊断早晚期、场景类型等。

采用描述性统计对比两种技术的核心性能差异，按“疾病亚型–应用场景”分层分析，通过可视化图表呈现关键指标，并结合临床需求解读技术适配性等问题。

3. 数据分析结果

3.1. 口腔鳞状细胞癌诊断层面

深度学习因跨模态学习和深层特征挖掘，适合异质性强的口腔鳞状细胞癌诊断[3]-[6]。

其中，基于 DenseNet201 与 GLCM、HOG、LBP 获取的形状、颜色和纹理特征的支持向量机(SVM)算法，准确率为 0.97 [7]。

表现出深度学习在处理具有明确形态学特征或高辨识度病理表现的复杂病理类型时，更加适合诊断。

传统影像组学在鳞状细胞癌形态特征分析中仍有价值，如结合临床分期与 MRI 放射组学特征预测舌鳞状细胞癌生存率，C 指数 0.86，精准预测了不良事件的风险和生存率[8]；牙龈鳞状细胞癌的 MRI 的 short-tau 反转恢复图像进行纹理分析可直接区分牙龈鳞状细胞癌和药物相关性颌骨坏死，适合基层诊断[9]；AI 模型在便携式设备中灵敏度 0.83，但需更多样本来进行优化[10]。

3.2. 口腔癌分期层面

早期口腔癌

传统影像组学与早期口腔癌分期研究关系密切的只有 Lan，但他使用的 Resenet50 模型，基于 MRI 的深度学习和放射组学。其测试的 AUC 值为 0.878 [2]。

深度学习的核心指标显著更优，研究关系密切的相关论文多。其在早期口腔癌分期中的数据如图 1 所示，深度学习各项数据均高于 0.92 [2] [7] [10] [11]-[26]。说明深度学习性能较传统影像组学较高。

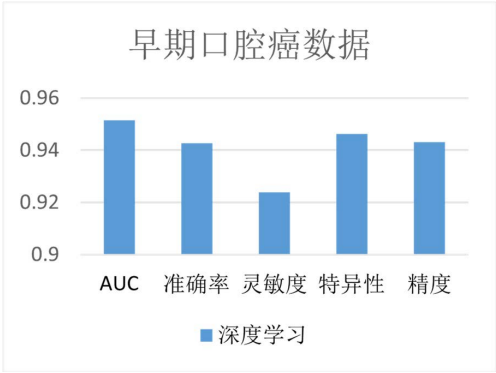

Figure 1. The mean values of each index for deep learning in the early-stage oral cancer test set
图 1. 深度学习在早期口腔癌测试组的各项均值

深度学习大都通过计算机视觉算法识别图像，其中八篇文献采用的模型中包括神经网络和卷积神经网洛[27]-[33]，更令人振奋的是，Lin Huiping [10]在 2021 年的文献中，使用基于智能手机进行口腔癌症早期诊断的自动诊断。

3.3. 口腔癌预后层面

3.3.1. 传统影像组学的预后特征

传统影像组学的口腔癌预后方面研究较多，有三篇预后预测文献和三篇生存预测文献[8] [34] [35]-

[40]。

其模型不尽相同，但总体来看，模型多整合放射组学特征与临床变量，提升预后预测准确性。Mes Steven W 等通过基于 MRI 的口腔和口咽癌症放射性预后模型，该模型的 iAUC 口腔(OS)为 0.69，iAUC 口咽(OS)为 0.70。之后，Mes 又通过整合放射学和临床变量，确定了最准确的模型，该模型的 iAUC 口腔(OS)达 0.72，iAUC 口咽(OS)达 0.81，优于单纯临床变量的预后模型($p < 0.001$) [34]。

3.3.2. 深度学习的预后突破

深度学习关于口腔癌预后的研究文献偏少，纳入的文献，只有 Fujima 的文献较为密切。

预后分类性能更优。在口腔鳞状细胞癌患者无病生存期(DFS)预测中，将患者分为“治疗控制组”与“失败组”时，深度学习诊断准确率达 0.8，灵敏度、特异性均为 0.8，显著优于 T 分期、临床分期。

在 Kaplan-Meier 分析中，DFS 率仅与基于深度学习的分类分析存在显著统计学差异 p 值小于 0.01 [41]。

深度学习更能反映口腔癌的预后特征，使医生给患者制定更加切合患者的预后方案提供更可靠。

4. 临床决策建议

根据图 2 的技术的直观表现，我们做出一下判断：

三级甲等医院等有实力的医院，在对鳞状细胞癌的诊断工作中，深度学习模型及算法应作为优先选择的技术方案。在具体模型的选用上，推荐采用视觉变换器或融合模型，以更好地满足精准诊断的技术需求。

对特殊要求的，如预测舌癌患者颈淋巴结隐匿性转移，传统影像组学更具有优势。

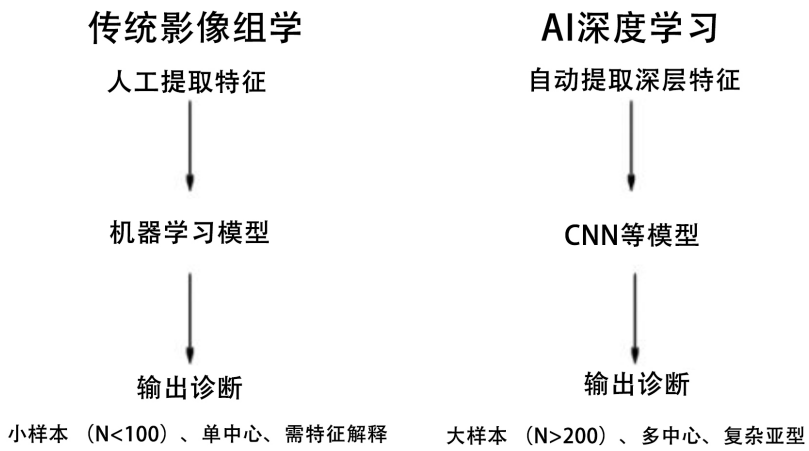

Figure 2. The technical principles and application scenarios of traditonal radiomics and deep learing
图 2. 传统影像组学和深度学习的技术原理与使用场景

基层医疗机构和低资源社区，智能手机影像筛查技术展现出重要价值。具体而言，应用 HRNet 模型可对口腔癌症的早期阶段进行自动检测与诊断，同时结合全景片进行二次验证，能有效降低诊断过程中的假阳性[42]。

5. 结论与展望

二者的应用场景并非“绝对优劣”，可采用两种技术交叉验证的方法，提高准确率。

传统技术在口腔癌转移检查的研究充分[43]-[47]，深度学习在这方面仍需研究。

针对早期口腔癌判断的传统影像组学的研究较少。针对其他期口腔癌的研究几乎没有。

未来仍需聚焦罕见亚型，扩大部分亚型(如牙龈鳞状细胞癌)的研究数据。非鳞状细胞癌的研究尚存空白。

智能手机图像筛查模型的研究论文不足，纳入文献中仅有两篇，未来可以进一步扩大研究数据，实现基于智能手机的口腔癌症早期诊断检测。

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参考文献

[1] Liu, X., Maleki, F., Muthukrishnan, N., Ovens, K., Huang, S.H., Pérez-Lara, A., *et al.* (2021) Site-Specific Variation in Radiomic Features of Head and Neck Squamous Cell Carcinoma and Its Impact on Machine Learning Models. *Cancers*, **13**, Article 3723. https://doi.org/10.3390/cancers13153723

[2] Lan, T., Kuang, S., Liang, P., Ning, C., Li, Q., Wang, L., *et al.* (2024) MRI-Based Deep Learning and Radiomics for Prediction of Occult Cervical Lymph Node Metastasis and Prognosis in Early-Stage Oral and Oropharyngeal Squamous Cell Carcinoma: A Diagnostic Study. *International Journal of Surgery*, **110**, 4648-4659. https://doi.org/10.1097/js9.0000000000001578

[3] Keser, G., Pekiner, F.N., Bayrakdar, İ.Ş., Çelik, Ö. and Orhan, K. (2024) A Deep Learning Approach to Detection of Oral Cancer Lesions from Intra Oral Patient Images: A Preliminary Retrospective Study. *Journal of Stomatology, Oral and Maxillofacial Surgery*, **125**, Article 101975. https://doi.org/10.1016/j.jormas.2024.101975

[4] Panigrahi, S., Das, J. and Swarnkar, T. (2022) Capsule Network Based Analysis of Histopathological Images of Oral Squamous Cell Carcinoma. *Journal of King Saud University-Computer and Information Sciences*, **34**, 4546-4553. https://doi.org/10.1016/j.jksuci.2020.11.003

[5] Ragab, M. and Asar, T.O. (2024) Deep Transfer Learning with Improved Crayfish Optimization Algorithm for Oral Squamous Cell Carcinoma Cancer Recognition Using Histopathological Images. *Scientific Reports*, **14**, Article No. 25348. https://doi.org/10.1038/s41598-024-75330-3

[6] Yang, S.Y., Li, S.H., Liu, J.L., Sun, X.Q., Cen, Y.Y., Ren, R.Y., *et al.* (2022) Histopathology-Based Diagnosis of Oral Squamous Cell Carcinoma Using Deep Learning. *Journal of Dental Research*, **101**, 1321-1327. https://doi.org/10.1177/00220345221089858

[7] Ahmad, M., Irfan, M.A., Sadique, U., Haq, I.u., Jan, A., Khattak, M.I., *et al.* (2023) Multi-Method Analysis of Histopathological Image for Early Diagnosis of Oral Squamous Cell Carcinoma Using Deep Learning and Hybrid Techniques. *Cancers*, **15**, Article 5247. https://doi.org/10.3390/cancers15215247

[8] Yao, Y., Jin, X., Peng, T., Song, P., Ye, Y., Song, L., *et al.* (2024) A Novel Nomogram for Predicting Overall Survival in Patients with Tongue Squamous Cell Carcinoma Using Clinical Features and MRI Radiomics Data: A Pilot Study. *World Journal of Surgical Oncology*, **22**, Article No. 227. https://doi.org/10.1186/s12957-024-03508-0

[9] Ito, K., Hirahara, N., Muraoka, H., Sawada, E., Tokunaga, S. and Kaneda, T. (2024) Texture Analysis Using Short-Tau Inversion Recovery Magnetic Resonance Images to Differentiate Squamous Cell Carcinoma of the Gingiva from Medication-Related Osteonecrosis of the Jaw. *Oral Radiology*, **40**, 219-225. https://doi.org/10.1007/s11282-023-00725-3

[10] Lin, H., Chen, H., Weng, L., Shao, J. and Lin, J. (2021) Automatic Detection of Oral Cancer in Smartphone-Based Images Using Deep Learning for Early Diagnosis. *Journal of Biomedical Optics*, **26**, Article 086007. https://doi.org/10.1117/1.jbo.26.8.086007

[11] Ahmed, I.A., Senan, E.M. and Shatnawi, H.S.A. (2023) Analysis of Histopathological Images for Early Diagnosis of Oral Squamous Cell Carcinoma by Hybrid Systems Based on CNN Fusion Features. *International Journal of Intelligent Systems*, **2023**, Article ID: 2662719. https://doi.org/10.1155/2023/2662719

[12] Fati, S.M., Senan, E.M. and Javed, Y. (2022) Early Diagnosis of Oral Squamous Cell Carcinoma Based on Histopathological Images Using Deep and Hybrid Learning Approaches. *Diagnostics*, **12**, Article 1899. https://doi.org/10.3390/diagnostics12081899

[13] Jeyaraj, P.R. and Samuel Nadar, E.R. (2019) Computer-Assisted Medical Image Classification for Early Diagnosis of Oral Cancer Employing Deep Learning Algorithm. *Journal of Cancer Research and Clinical Oncology*, **145**, 829-837. https://doi.org/10.1007/s00432-018-02834-7

[14] Jubair, F., Al-karadsheh, O., Malamos, D., Al Mahdi, S., Saad, Y. and Hassona, Y. (2022) A Novel Lightweight Deep Convolutional Neural Network for Early Detection of Oral Cancer. *Oral Diseases*, **28**, 1123-1130.

https://doi.org/10.1111/odi.13825

[15] Wang, W., Liu, Y. and Wu, J. (2023) Early Diagnosis of Oral Cancer Using a Hybrid Arrangement of Deep Belief Networkand Combined Group Teaching Algorithm. *Scientific Reports*, **13**, Article No. 22073. https://doi.org/10.1038/s41598-023-49438-x

[16] Shamim, M.Z.M., Syed, S., Shiblee, M., Usman, M., Ali, S.J., Hussein, H.S., *et al.* (2020) Automated Detection of Oral Pre-Cancerous Tongue Lesions Using Deep Learning for Early Diagnosis of Oral Cavity Cancer. *The Computer Journal*, **65**, 91-104. https://doi.org/10.1093/comjnl/bxaa136

[17] Soni, A., Sethy, P.K., Dewangan, A.K., Nanthaamornphong, A., Behera, S.K. and Devi, B. (2024) Enhancing Oral Squamous Cell Carcinoma Detection: A Novel Approach Using Improved Efficientnet Architecture. *BMC Oral Health*, **24**, Article No. 601. https://doi.org/10.1186/s12903-024-04307-5

[18] Dutta, C., Sandhya, P., Vidhya, K., Rajalakshmi, R., Ramya, D. and Madhubabu, K. (2024) Effectiveness of Deep Learning in Early-Stage Oral Cancer Detections and Classification Using Histogram of Oriented Gradients. *Expert Systems*, **41**, e13439. https://doi.org/10.1111/exsy.13439

[19] Xue, Z., Yu, K., Pearlman, P.C., Pal, A., Chen, T., Hua, C., *et al.* (2022) Automatic Detection of Oral Lesion Measurement Ruler toward Computer-Aided Image-Based Oral Cancer Screening. 2022 44*th Annual International Conference of the IEEE Engineering in Medicine & Biology Society* (*EMBC*), Glasgow, 11-15 July 2022, 3218-3221. https://doi.org/10.1109/embc48229.2022.9871610

[20] Pham, T.D. (2024) Integrating Support Vector Machines and Deep Learning Features for Oral Cancer Histopathology Analysis. medRxiv.

[21] Li, L., Pu, C., Tao, J., Zhu, L., Hu, S., Qiao, B., *et al.* (2024) Development of an Oral Cancer Detection System through Deep Learning. *BMC Oral Health*, **24**, Article No. 1468. https://doi.org/10.1186/s12903-024-05195-5

[22] Chen, R., Wang, Q. and Huang, X. (2024) Intelligent Deep Learning Supports Biomedical Image Detection and Classification of Oral Cancer. *Technology and Health Care*, **32**, 465-475. https://doi.org/10.3233/thc-248041

[23] Yang, Z., Pan, H., Shang, J., Zhang, J. and Liang, Y. (2023) Deep-Learning-Based Automated Identification and Visualization of Oral Cancer in Optical Coherence Tomography Images. *Biomedicines*, **11**, Article 802. https://doi.org/10.3390/biomedicines11030802

[24] Albalawi, E., Thakur, A., Ramakrishna, M.T., Bhatia Khan, S., SankaraNarayanan, S., Almarri, B., *et al.* (2024) Oral Squamous Cell Carcinoma Detection Using Efficientnet on Histopathological Images. *Frontiers in Medicine*, **10**, Article ID: 1349336. https://doi.org/10.3389/fmed.2023.1349336

[25] Yuan, W., Yang, J., Yin, B., Fan, X., Yang, J., Sun, H., *et al.* (2023) Noninvasive Diagnosis of Oral Squamous Cell Carcinoma by Multi-Level Deep Residual Learning on Optical Coherence Tomography Images. *Oral Diseases*, **29**, 3223-3231. https://doi.org/10.1111/odi.14318

[26] Yuan, W., Cheng, L., Yang, J., Yin, B., Fan, X., Yang, J., *et al.* (2022) Noninvasive Oral Cancer Screening Based on Local Residual Adaptation Network Using Optical Coherence Tomography. *Medical & Biological Engineering & Computing*, **60**, 1363-1375. https://doi.org/10.1007/s11517-022-02535-x

[27] Singha, D.B., Mayukha, P., Prasanta, K, P. and Asima, P. (2022) Supremacy of Attention Based Convolution Neural Network in Classification of Oral Cancer Using Histopathological Images. medRxiv.

[28] Fu, Q., Chen, Y., Li, Z., Jing, Q., Hu, C., Liu, H., *et al.* (2020) A Deep Learning Algorithm for Detection of Oral Cavity Squamous Cell Carcinoma from Photographic Images: A Retrospective Study. *eClinicalMedicine*, **27**, Article 100558. https://doi.org/10.1016/j.eclinm.2020.100558

[29] Shavlokhova, V., Sandhu, S., Flechtenmacher, C., Koveshazi, I., Neumeier, F., Padrón-Laso, V., *et al.* (2021) Deep Learning on Oral Squamous Cell Carcinoma *Ex Vivo* Fluorescent Confocal Microscopy Data: A Feasibility Study. *Journal of Clinical Medicine*, **10**, Article 5326. https://doi.org/10.3390/jcm10225326

[30] Pandiar, D., Choudhari, S. and Poothakulath Krishnan, R. (2023) Application of Inceptionv3, Squeezenet, and VGG16 Convoluted Neural Networks in the Image Classification of Oral Squamous Cell Carcinoma: A Cross-Sectional Study. *Cureus*, **15**, e49108. https://doi.org/10.7759/cureus.49108

[31] Warin, K., Limprasert, W., Suebnukarn, S., Jinaporntham, S. and Jantana, P. (2021) Automatic Classification and Detection of Oral Cancer in Photographic Images Using Deep Learning Algorithms. *Journal of Oral Pathology & Medicine*, **50**, 911-918. https://doi.org/10.1111/jop.13227

[32] Ananthakrishnan, B., Shaik, A., Kumar, S., Narendran, S.O., Mattu, K. and Kavitha, M.S. (2023) Automated Detection and Classification of Oral Squamous Cell Carcinoma Using Deep Neural Networks. *Diagnostics*, **13**, Article 918. https://doi.org/10.3390/diagnostics13050918

[33] Devindi G.A.I., Dissanayake D.M.D.R., Liyanage S.N., *et al.* (2024) Multimodal Deep Convolutional Neural Network Pipeline for AI-Assisted Early Detection of Oral Cancer. *IEEE Access*, **12**, 124375-124390.

[34] Mes, S.W., van Velden, F.H.P., Peltenburg, B., Peeters, C.F.W., te Beest, D.E., van de Wiel, M.A., *et al.* (2020) Outcome Prediction of Head and Neck Squamous Cell Carcinoma by MRI Radiomic Signatures. *European Radiology*, **30**, 6311-6321. https://doi.org/10.1007/s00330-020-06962-y

[35] Dhanya, K., Prasad, D.V.V. and Lokeswari, Y.V. (2024) Detection of Oral Squamous Cell Carcinoma Using Pre-Trained Deep Learning Models. *Experimental Oncology*, **46**, 119-128. https://doi.org/10.15407/exp-oncology.2024.02.119

[36] Qayyum, A., Benzinou, A., Razzak, I., Mazher, M., Nguyen, T.T., Puig, D., *et al.* (2024) 3D-Incnet: Head and Neck (H&N) Primary Tumors Segmentation and Survival Prediction. *IEEE Journal of Biomedical and Health Informatics*, **28**, 1185-1194. https://doi.org/10.1109/jbhi.2022.3219445

[37] Kaźmierska, J., Kaźmierski, M.R., Bajon, T., Winiecki, T., Bandurska-Luque, A., Ryczkowski, A., *et al.* (2022) Prediction of Incomplete Response of Primary Tumour Based on Clinical and Radiomics Features in Inoperable Head and Neck Cancers after Definitive Treatment. *Journal of Personalized Medicine*, **12**, Article 1092. https://doi.org/10.3390/jpm12071092

[38] Pan, X., Zhang, T., Yang, Q., Yang, D., Rwigema, J. and Qi, X.S. (2020) Survival Prediction for Oral Tongue Cancer Patients via Probabilistic Genetic Algorithm Optimized Neural Network Models. *The British Journal of Radiology*, **93**, Article 20190825. https://doi.org/10.1259/bjr.20190825

[39] Yuan, W., Rao, J., Liu, Y., *et al.* (22024) Deep Radiomics-Based Prognostic Prediction of Oral Cancer Using Optical Coherence Tomography. *BMC Oral Health*, **4**, Article No. 1117.

[40] Song, Y., Tian, Y., Lu, X., Chen, G. and Lv, X. (2024) Prognostic Value of ^{18}F-FDG PET Radiomics and Sarcopenia in Patients with Oral Squamous Cell Carcinoma. *Medical Physics*, **51**, 4907-4921. https://doi.org/10.1002/mp.16949

[41] Fujima, N., Andreu-Arasa, V.C., Meibom, S.K., Mercier, G.A., Salama, A.R., Truong, M.T., *et al.* (2020) Deep Learning Analysis Using FDG-PET to Predict Treatment Outcome in Patients with Oral Cavity Squamous Cell Carcinoma. *European Radiology*, **30**, 6322-6330. https://doi.org/10.1007/s00330-020-06982-8

[42] Uthoff, R.D., Song, B., Sunny, S., Patrick, S., Suresh, A., Kolur, T., *et al.* (2018) Point-of-Care, Smartphone-Based, Dual-Modality, Dual-View, Oral Cancer Screening Device with Neural Network Classification for Low-Resource Communities. *PLOS ONE*, **13**, e0207493. https://doi.org/10.1371/journal.pone.0207493

[43] Wang, D., He, X., Huang, C., Li, W., Li, H., Huang, C., *et al.* (2024) Magnetic Resonance Imaging-Based Radiomics and Deep Learning Models for Predicting Lymph Node Metastasis of Squamous Cell Carcinoma of the Tongue. *Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology*, **138**, 214-224. https://doi.org/10.1016/j.oooo.2024.01.016

[44] Kubo, K., Kawahara, D., Murakami, Y., Takeuchi, Y., Katsuta, T., Imano, N., *et al.* (2022) Development of a Radiomics and Machine Learning Model for Predicting Occult Cervical Lymph Node Metastasis in Patients with Tongue Cancer. *Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology*, **134**, 93-101. https://doi.org/10.1016/j.oooo.2021.12.122

[45] Agheli, R., Siavashpour, Z., Reiazi, R., Azghandi, S., Cheraghi, S. and Paydar, R. (2024) Predicting Severe Radiation-Induced Oral Mucositis in Head and Neck Cancer Patients Using Integrated Baseline CT Radiomic, Dosimetry, and Clinical Features: A Machine Learning Approach. *Heliyon*, **10**, e24866. https://doi.org/10.1016/j.heliyon.2024.e24866

[46] Liu, J., Corti, A., Calareso, G., Spadarella, G., Licitra, L., Corino, V.D.A., *et al.* (2024) Developing a Robust Two-Step Machine Learning Multiclassification Pipeline to Predict Primary Site in Head and Neck Carcinoma from Lymph Nodes. *Heliyon*, **10**, e24377. https://doi.org/10.1016/j.heliyon.2024.e24377

[47] Prasse, G., Glaas, A., Meyer, H., Zebralla, V., Dietz, A., Hering, K., *et al.* (2023) A Radiomics-Based Machine Learning Perspective on the Parotid Gland as a Potential Surrogate Marker for HPV in Oropharyngeal Cancer. *Cancers*, **15**, Article 5425. https://doi.org/10.3390/cancers15225425