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Usage of Magnetic Resonance Imaging-Based Texture Analysis Features in Discrimination of Benign and Malignant Sinonasal Tumors

Benign ve Malign Sinonazal Tümörlerin Ayırımında Manyetik Rezonans Görüntüleme Tabanlı Doku Analizi Özelliklerinin Kullanımı

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Abstract

Aim: The objective of this study was to differentiate between benign and malignant sinonasal tumors using magnetic resonance imaging (MRI)-based texture analysis features.

Material and Method: Histopathologically proven benign or malignant sinonasal tumor patients were included in the study from MRI examinations performed between January 2013 and December 2020. Inclusion criteria included a tumor size of at least 1 cm and preoperative magnetic resonance imaging with axial T1W, axial fat-suppressed T2W, and axial T1W postcontrast sequences. After the images were transferred to a dedicated workstation, texture analysis calculations were performed. Differences between benign and malignant groups were compared.

Results: The mean age of 37 patients (8 female, 29 male) included in the study was 50.8 ± 21.9 years. In our study, we found no statistically significant difference between malignant and benign sinonasal tumors in nine tissue analysis parameters obtained by MRI.

Conclusion: MRI-based texture analysis needs identical MRI protocols for evaluating tumors. MRI-based texture analysis is not a useful diagnostic tool to discriminate between benign and malignant sinonasal tumors when specific pathologic types are not selected and scanning protocols are not identical.

Keywords: Magnetic resonance imaging, sinonasal, tumor, texture analysis

Öz

Amaç: Bu çalışmanın amacı, manyetik rezonans görüntüleme (MRG) tabanlı doku analizi özelliklerini kullanarak benign ve malign sinonazal tümörleri ayırt etmektir.

Gereç ve Yöntem: Ocak 2013 ile Aralık 2020 tarihleri arasında çekilmiş MRG incelemelerinden histopatolojik olarak kanıtlanmış benign ya da malign sinonazal tümor hastaları çalışmaya dahil edildi. Dahil edilme kriterleri 1 cm'den büyük tumor boyutu ve MR görüntülerinde T1 aksiyal, T2 aksiyal ve kontrastlı T1 aksiyal sekansların bulunmasıdır. Görüntüler iş istasyonuna aktarıldıktan sonra doku analizi hesaplamaları yapıldı. Benign ve malign gruplar arasındaki farklılıklar karşılaştırıldı.

Bulgular: Çalışmaya dahil edilen 37 hastanın ortalama yaşı 50,8±21,9 (8 kadın, 29 erkek). Çalışmamızda MRI ile elde edilen dokuz doku analiz parametresi malign ve benign sinonazal tümörler arasında istatistiksel olarak farklılık bulmadık.

Sonuç: MRG tabanlı doku analizi ile tümörlerin değerlendirilmesinde çekim protokollerinin aynı olması gerekmektedir. Spesifik patolojik tipler seçilmediğinde ve çekim protokolleri aynı olmadığında sinonazal tümörlerde benign ve malign ayrımında MRG tabanlı doku analizi yararlı değildir.

Anahtar Kelimeler: Manyetik rezonans görüntüleme, sinonazal, tümör, doku analizi

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INTRODUCTION

Sinonasal tumors constitute 3% of head and neck cancers and 1% of all malignancies. Patients in most cases are asymptomatic. Clinical signs are generally non-specific and include nasal discharge, nasal obstruction, lacrimation, and epistaxis. The primary etiological factor reported is occupational exposure. A number of agents have been identified as increasing the risk of sinonasal carcinoma, including wood dust, which is particularly associated with adenocarcinoma, leather dust, welding fume, nickel, arsenic, and chromium.[1,2]

Paranasal sinuses and nasal cavity are commonly evaluated with computed tomography (CT) imaging in clinical practice. It is accepted as the gold standard technique, particularly for inflammatory lesions.[3] Beside this, the sinonasal region contains various histopathological types of benign and malignant tumors. Bony destruction caused by a tumor is accepted as a malignancy criterion in CT imaging. Determination of an exact diagnosis and prediction of the clinical outcome need histopathological evaluation of the surgical specimen in sinonasal tumors. Presurgical and non-invasive differentiation between benign and malignant sinonasal tumors using radiological imaging modalities is crucial and effects surgical treatment approach and clinical prognosis. Radiologists commonly strive to discriminate benign tumors from malignant ones in head and neck. Magnetic resonance imaging (MRI) is a diagnostic modality with high soft tissue resolution. It is commonly used in the diagnosis and characterization of sinonasal tumors, particularly when malignancy is suspected. MRI provides anatomic details, and also gives additional metabolic and biologic information in tumors.[4-8]

In the field of medicine, texture analysis is a mathematical approach used for non-invasive evaluation of the spatial variability of regions of interest (ROI) in medical images.[9,10] It is commonly used in non-invasive characterization and grading of tumors. In the past decade, there has been a growing interest in the use of texture analysis for the diagnosis, prediction of treatment outcomes, and association with tumor genomic properties in head and neck tumors.[6,11-13]

The objective of the present study was to ascertain whether texture analysis features derived from MRI scans can distinguish between benign and malignant sinonasal tumors.

MATERIAL AND METHOD

Patients

This retrospective study was approved by the local ethics committee (file number: 2020/231). A radiology database search was conducted in our hospital. All MRI examinations performed from January 2013 to December 2020 at our institution were scanned. Patients who have a pathologically proven benign and/or malignant sinonasal tumor having a size of 1 cm or larger in MRI examinations were included. 45 patients with sinonasal neoplasm who underwent pre-surgical head and neck MRI were identified. Three patients were excluded from the study due to the presence of motion artifacts in their images. Tumors smaller than 1 cm were not included (n=2). Three patients were excluded because MRI images did not include postcontrast series .

MRI Examinations

All MRI examinations were performed with a 1.5 Tesla MRI platform (Siemens, Magnetom, Aera and, Toshiba, Vantage, Titan) in supine position by using an 8-channel head coil. MRI protocol included non-contrast T1W axial (TR, 505 ms; TE, 8.8 ms; acquisition matrix, 256×168; field of view, 19x21 cm; slice thickness, 5.5 mm), and coronal (TR, 464 ms; TE, 8.7 ms; acquisition matrix, 320×224; field of view, 22x22 cm; slice thickness, 4.5 mm), T2W sagittal (TR, 5000 ms; TE, 81ms; acquisition matrix, 320×224; field of view, 22×22 cm; slice thickness, 4 mm), fat suppressed T2W axial (TR, 5150 ms; TE, 80 ms; acquisition matrix, 320×210; field of view, 19×21 cm; slice thickness, 5.5 mm), coronal (TR, 3100 ms; TE, 51 ms; acquisition matrix, 320×224; field of view, 22×22 cm; slice thickness, 4.5 mm), postcontrast T1W axial and coronal images.

Image Analysis and Post-processing

The relationship and distribution of pixel intensities in an image are analyzed by texture analysis, which yields a quantitative assessment of tumor heterogeneity. For texture analysis and segmentation, all images were loaded into the software program (OLEA Sphere 3.0, OLEA Medical, France). Interpretation and postprocessing steps of images were performed by a seven-year-experienced neuroradiologist without knowing final histopathological results. T1W axial, fat suppressed FS-T2W axial, and post-contrast T1W axial images were used to calculate the texture analysis features. An ROI of 30-50 mm² was manually drawn on the solid part of the tumor in the mentioned sequences. Cystic and necrotic parts were avoided. **Figure 1** shows the placement of the ROI to the tumor. Six first-order intensity based features (entropy, mean, median, skewness, kurtosis, variance) and three gray level co-occurrence matrix based features (contrast, correlation, joint energy) among texture analysis parameters were calculated for each ROI.

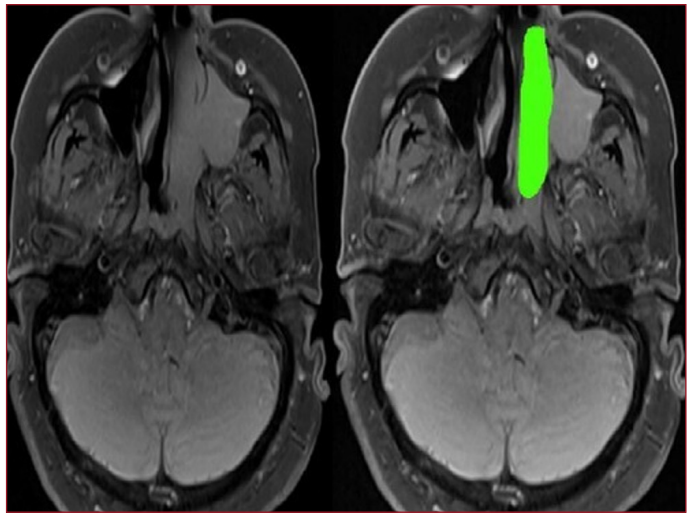

Figure 1. Tumor in the left nasal cavity on T1A sequence and placement of the region of interest on the solid part of the tumor.

Statistical Analysis

The statistical analysis was performed using SPSS Version 21.0. Kolmogorov-Smirnov test was used to assess whether the variable distributed normally or abnormally. The variables were given as median (min-max) since the data did not show normal distribution. Mann-Whitney U test was used in comparison of the groups.

RESULTS

Thirty seven patients with histopathological proven sinonasal tumor enrolled in the study. The mean age of the patients was 50 years (range, 12–90 years) at the time of diagnosis. 29 (78%) patients were male and 8 (28%) were female (**Table 1**). Malignant sinonasal tumor group included seven patients and all were male. Demographic characteristics of patients are presented in **Table 1** and texture analysis parameters of benign and malignant sinonasal neoplasms are presented in **Tables 2**, **3**, and **4**.

Table 1: Demographic characteristics of patients

	Benign (n=30)	Malignant (n=7)
Age - median(min-max)	51 (14-90 years)	55 (12-72) years
Gender (M/F)	22/8	7/0

Table 2: Texture analysis features of benign and malignant sinonasal tumors on T1W sequence.

	Benign	Malignant	P value
Entropy	4.8 (3.9-5.8)	4.3 (4-5.5)	0.458
Mean	298.4 (134.6-1640.9)	317.3 (253.1-1439)	0.582
Median	299 (137-1639.8)	319 (264-1461.6)	0.435
Skewness	-0.2 (-3.9-2.6)	-0.4 (-2.5-1.2)	0.391
Kurtosis	5.1 (1.7-22.8)	5.6 (1.9-13.1)	0.506
Variance	1658.9 (109.9-345973.6)	2108.4 (774.3-46888.6)	0.556
Contrast	14.9 (1.7-21790)	8 (3.5-43.9)	0.413
Correlation	0.9 (-0.1-0.9)	0.9 (0.7-0.9)	0.805
Joint energy	0 (0-0.1)	0 (0-0)	0.312

Variables are expressed as median (min-max). T1W: T1 weighted

Table 3: Texture analysis features of benign and malignant sinonasal tumors on FS-T2W sequence.

	Benign	Malignant	P value
Entropy	5.2 (4.2-5.7)	5.2 (3.5-5.6)	0.938
Mean	618.4 (258.1-1497.6)	444.6 (62-1243.9)	0.287
Median	613.5 (244.5-1470.8)	448 (29-1258.7)	0.221
Skewness	-0.1 (-1.7-1.7)	0.35 (-0.9-3.6)	0.153
Kurtosis	3.1 (1.4-12.6)	3.2 (2.6-19.2)	0.433
Variance	37204.7 (4052.3-279488.3)	28314.3 (7591-212481)	0.667
Contrast	27 (7.2-1208.7)	26.4 (4.7-35.1)	0.410
Correlation	0.8 (-0.4-0.9)	0.8 (0-0.9)	0.725
Joint energy	0 (0-0.3)	0 (0-0)	0.815

Variables are expressed as median (min-max). FS-T2W: fatsuppressed T2 weighted

Table 4: Texture analysis features of benign and malignant sinonasal tumors on CE-T1W sequence.

	Benign	Malignant	P value
Entropy	5.1 (3.8-5.7)	5 (4.7-5.5)	0.719
Mean	684.3 (297-2885)	565.3 (376.1-2127.7)	0.776
Median	677 (307-2882.2)	579 (338-2107.1)	0.865
Skewness	-0.3 (-0.1-1.7)	0 (-1.4-1.5)	0.835
Kurtosis	3.7 (1.6-16.5)	4.1 (2.4-6.2)	0.435
Variance	16421.4 (2062.5-166204.5)	14444.8 (3045.3-438620.3)	0.805
Contrast	13.5 (2.5-75.7)	11.2 (6.3-125.3)	0.894
Correlation	0.9 (0.4-0.9)	0.9 (0.6-0.9)	0.531
Joint Energy	0 (0-0)	0 (0-0)	0.293

Variables are expressed as median (min-max). CE-T1W: contrast enhanced T1 weighted.

There were 30 patients diagnosed with benign pathology in our study. The histopathological types of the tumors were nasal polyp (n=13), inverted papilloma (n=11), paraganglioma (n=1), angiofibroma (n=2), vascular leiomyoma (n=2), plasmocytoma (n=1). In addition, there were 7 patients diagnosed with malignant pathology in our study. The histopathological types of the tumors were Ewing sarcoma (n=1), non-keratinized carcinoma (n=1), olfactory neuroblastoma (n=1), verrucous carcinoma (n=1), lymphoma (n=1).

In our study, texture analysis of six first-order intensity-based features (entropy, mean, median, skewness, kurtosis, variance) and three gray-level co-occurrence matrix-based features (contrast, correlation, joint energy) was studied between benign and malignant sinonasal tumor groups. We found no statistically significant difference in T1W, FS-T2W and CE-T1W sequences. (p≥0.05) (**Tablea 2-4**).

DISCUSSION

The present study employed texture analysis with first-order intensity-based and gray-level co-occurrence matrix-based features on T1W, FS-T2W, and postcontrast T1W MRI. The results indicated that there was no significant difference between benign and malignant sinonasal tumors.

Texture analysis is a mathematical method and includes multiple various parameters. Dedicated software was developed for texture analysis in the last decade. Various imaging modalities can be used for texture analysis, such as MRI, CT, perfusion weighted imaging, susceptibility weighted imaging, positron emission tomography, and ultrasonography. However, MRI is the most preferred imaging technique for performing texture analysis of head and neck tumors in previous literature. When previous studies regarding MRI-based texture analysis in the literature are investigated, it is not possible to make one-to-one comparisons because of the differences between the parameters and sequences included in the study, and even the shooting parameters in the same sequences. There are few previous reports that investigated the role of MRI-based texture analysis in sinonasal tumors in last decade. In a recent multicenter study conducted by Fruehwald-Pallamar et al.[11]

the role of MRI-based texture analysis in 100 head and neck tumor is investigated. The authors of that study used FS-T2W images and concluded that MRI-based texture analysis has the potential for differentiation of benign and malignant tumors in the head and neck region, but they indicated that the same MRI scanner with an identical MRI protocol is needed to achieve good results. Different MRI equipment and imaging protocols cause unreliable results. Our results supported this conclusion, though benign and malignant groups in the present study included various tumor types and MRI examination protocols were not identical. Another study investigated texture analysis in parotid tumors and reported that MRI-based texture analysis is able to discriminate between benign and malignant parotid gland tumors.[14] In a recent article conducted by Fujima et al.[5] SCC and lymphoma located in head and neck region were compared in terms of texture analysis features, and it was concluded that FS-T2WI-based texture analysis may provide useful data for imaging prediction of histopathological type and grade in head and neck malignancy. Ramkumar et. al.[13] investigated the role of MRI-based texture analysis to differentiate inverted papillomas from sinonasal SCCs. They used T1W axial, T2W axial, and postcontrast T1W axial sequences. The results of their study concluded that MRI-based texture analysis has the potential for discrimination of inverted papillomas and SCCs. Previous reports in the literature commonly included homogeneous tumor groups. We think the small cohort sample, heterogeneity in benign and malignant groups, and different MRI scanners with different imaging protocols are responsible for the unsuccessful performance of MRI-based texture analysis in the present study.

This study has some limitations. Primarily, the sample sizes of both benign and malignant groups were small. Particularly, the malignant group consist of only 7 lesions. Second, two groups were heterogeneous in terms of histopathological tumor types. As the authors of the present study, we think this is the major factor that caused the insignificant difference between benign and malignant sinonasal tumors. The analysis of a large number of patients and more homogeneous tumor groups may reveal significant differences in these tumors through texture analysis. Third, the examinations were performed on two different MRI equipment, and the imaging protocols were not identical. This may influence texture analysis parameters. Beside these, the fact that all patients included in the study had a pathological diagnosis is the superior aspect of the present study.

CONCLUSION

MRI-based texture analysis is not a reliable and practical diagnostic tool for discriminating between benign and malignant sinonasal tumors when different MRI scanners and non-identical protocols are used. Future studies with homogenous and larger study populations are needed to assess the diagnostic performance of MRI-based texture analysis in sinonasal tumors.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Selçuk University Local Ethics Committee (Date: 03.06.2020, Decision No: 2020/231).

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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REFERENCES

1. Truong T, Perez-Ordoñez B. Selected epithelial sinonasal neoplasms: an update. Diagnostic Histopathology 2019;25(7):281-8.
2. Guizani MA, Jrad M, Benjelloun GT, et al. editors. Sinonasal neoplasms: key points of the report 2019: European Congress of Radiology 2019.
3. Pirimoğlu B, Sade R. Paranazal sinüs görüntülemede 320-sıralı multidedektör bilgisayarlı tomografi kullanarak düşük doz ve yüksek kalitede görüntü elde edebilir miyiz? Van Tıp Derg 2018;25:22-7.
4. Peker A, Peker E, Erden İ. Benign ve malign sinonazal kitlelerin ayrımında difüzyon MR görüntüleme. Dicle Tıp Derg 2014;41:522-5.
5. Fujima N, Homma A, Harada T, et al. The utility of MRI histogram and texture analysis for the prediction of histological diagnosis in head and neck malignancies. Cancer Imaging 2019;19:5.
6. Dang M, Lysack J, Wu T, et al. MRI texture analysis predicts p53 status in head and neck squamous cell carcinoma. Am J Neuroradiol 2015;36:166-70.
7. Gencturk M, Ozturk K, Caicedo-Granados E, et al. Application of diffusion-weighted MR imaging with ADC measurement for distinguishing between the histopathological types of sinonasal neoplasms. Clin Imaging 2019;55:76-82.
8. Agarwal M, Policeni B. Sinonasal Neoplasms. Semin Roentgenol. 2019;54(3):244-257.
9. Davnall F, Yip CS, Ljungqvist G, et al. Assessment of tumor heterogeneity: an emerging imaging tool for clinical practice?. Insights Imaging. 2012;3(6):573-89.
10. Choi JY. Radiomics and deep learning in clinical imaging: what should we do? Nucl Med Mol Imaging 2018;52:89-90.
11. Fruehwald-Pallamar J, Hesselink JR, Mafee MF, Holzer-Fruehwald L, Czerny C, Mayerhoefer ME. Texture-Based Analysis of 100 MR Examinations of Head and Neck Tumors - Is It Possible to Discriminate Between Benign and Malignant Masses in a Multicenter Trial?. Rofo. 2016;188(2):195-202.
12. Jansen JF, Lu Y, Gupta G, et al. Texture analysis on parametric maps derived from dynamic contrast-enhanced magnetic resonance imaging in head and neck cancer. World J Radiol. 2016;8(1):90-7.
13. Ramkumar S, Ranjbar S, Ning S, et al. MRI-Based Texture Analysis to Differentiate Sinonasal Squamous Cell Carcinoma from Inverted Papilloma. AJNR Am J Neuroradiol. 2017;38(5):1019-25.
14. Fruehwald-Pallamar J, Czerny C, Holzer-Fruehwald L, et al. Texture-based and diffusion-weighted discrimination of parotid gland lesions on MR images at 3.0 Tesla. NMR Biomed. 2013;26(11):1372-9.