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Preoperative Endoscopic Sinus Surgery Planning of Inverted Papilloma: Comparative Usefulness of MRI in Identifying Tumor Origin

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ABSTRACT

Background and Objectives: The purpose of this study was to evaluate the role of T2-weighted image (T2WI) in identifying the site of origin of inverted papilloma (IP) and to assess the diagnostic utility of the T2 peritumoral hyperintense layer on MRI in cases without focal hyperostosis on computed tomography (CT), which is otherwise a well-established marker for tumor origin. **Materials and Methods:** We retrospectively analyzed 51 patients with pathologically confirmed IP who underwent both CT and MRI. The tumor origin site was confirmed intraoperatively. The image analysis of all CT and MRI was done by two experienced neuroradiologists. We analyzed the origin site of IP on Gd-T1WI and T2WI. The radiologic predictions were compared to the surgically proved origin sites. We analyzed the predictive accuracy of Gd-T1WI and T2WI separately. **Results:** Of the 51 cases, IP masses were located in the nasal cavity commonly (n=14), followed by maxillary sinus (n=12). Multi-sinus involvement including the nasal cavity was 25 cases. Surgically confirmed IP origin was in the maxillary sinus (n=16), frontal sinus (n=4), ethmoid sinus (n=14), sphenoid sinus (n=2) and nasal cavity (n=15). Compared to the surgically confirmed origin sites, the positive prediction of IP origin was 21 cases on Gd-T1WI (21/51, 41.2%) and 43 cases (43/51, 84.3%) on T2WI. The predictive accuracy of T2WI was better in 22 cases and similar in 21 cases, compared to Gd-T1WI. **Conclusion:** In cases without hyperostosis on CT, MRI provides critical complementary information for identifying the IP origin with hyperintense peritumoral change on MR T2WI. T2WI demonstrated significantly greater accuracy than Gd-T1WI in localizing the origin of the sinonasal IP. Therefore, T2WI may be particularly useful for detecting non-adherent areas, aiding in more accurate preoperative planning and complete resection.

KEY WORDS: Papilloma, Inverted; Endoscopic sinus surgery; Computed tomography; Magnetic resonance imaging, T2-weighted imaging; Preoperative planning.

Introduction

Inverted papilloma (IP) is a benign tumor originating from the Schneiderian mucosa of the nasal cavity and paranasal sinuses. Despite its benign nature, IP demonstrates locally aggressive behavior with a high rate of recurrence and the potential for malignant transformation in approximately 5%–15% of cases.[1,2] Preoperative imaging, particularly CT

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and MRI, plays a critical role in the diagnosis, localization, and surgical planning of IP.[3–7)]

On CT, the site of origin can often be inferred from focal hyperostosis, believed to result from chronic irritation and associated bone remodeling.[5,8,9)] However, this finding is not present in all patients (about 63.2%), which may lead to incomplete resection if the origin site is overlooked.[6)]

MRI is more useful for characterizing the lesion itself. The most characteristic finding on MRI is a cerebriform pattern of contrast enhancement, which is often not appreciable on CT.[10,11)] Conversely, hyperostosis is difficult to detect using MRI.[7)] In cases lacking hyperostosis on CT, careful evaluation using T2-weighted images (T2WIs) may help identify the site of origin. A peritumoral hyperintense layer, representing peritumoral mucosal edema or inflammation, can often be observed surrounding the lesion.[12,13)] This T2 peritumoral hyperintense layer contrasts with the intermediate signal intensity of the tumor itself and may serve as an indirect marker of the tumor origin.

The purpose of this study was to evaluate the role of T2WI in identifying the site of origin of IP and to assess the diagnostic utility of the T2 peritumoral hyperintense layer on MRI in cases without focal hyperostosis on CT, which is otherwise a well-established marker for tumor origin.

Materials and Methods

Patients

All patients underwent both CT and MRI before surgery between May 2007 – June 2025. The patients showing hyperostosis on CT were excluded. All patients underwent endoscopic sinus surgery (ESS), and the site of tumor origin was confirmed intraoperatively. 51 patients (39 males and 12 females: age range, 27-87 years; mean age, 57.0 years) with pathologically proven IP in the nasal cavity or paranasal sinus by surgery, were included. This study was approved by the Institutional Review Board of our hospital (IRB No. 2506-015-152).

CT and MR Imaging

The paranasal sinus CT scans were obtained preoperatively in axial and coronal planes in helical CT scanners (Cti, lightSpeed Plus, Discovery, Revolution, Revolution FT, Revolution RC, Revolution Apex, Revolution Max; GE Medical System, Milwaukee, WI, USA; Sensation 16, Definition, Somatom Plus; Siemens, Erlangen, Germany). CT parameters were shown on Table 1. MRI was performed on 1.5 and 3.0 T systems (SMS Skyra, Avanto, Vida, TrioTim and Symphony; Siemens, Erlangen, Germany, GMS Architect, GMS Premier; GE medical system, Milwaukee, WI, USA). The MRI protocols were shown on Table 2.

Image analysis

The image analysis of all CT and MRI was performed by two radiologists who have been practicing for 30 years and 23 years. All CT and MR images were reviewed retrospectively by the consensus of two experienced neuroradiologists (H.J.K. and Y.W.K.). Assessment of the hyperostosis of the nasal and maxillary bone was performed on CT for exclusion of the present study. When evaluating hyperostosis in the paranasal sinuses, we considered only focal hyperostosis to be a positive finding. Focal hyperostosis was defined as eccentric bone thickening and sclerosis that involved only a limited portion of the wall of a given paranasal sinus. The

Table 1. CT Parameters

CT parameters	CTi	Light speed plus	Sensation 16	Definition	GMS discovery 750	GMS revolution	SMS definition	SMS somatom plus	GMS revolution RC	GMS revolution max
Tube voltage (KV)	120	120	120	120	120	120	120	100	120	120
Tube current (mA)	200	200	200	160	90	90	62–75	433	99	90
ST (ax)	0.63	0.63	2	2	1	1	1	1	1	2.5
ST (co)	2.5	0.5	0.625	0.625	1	1	1	1	1	1

Table 2. MR Parameters

MR parameters		Skyra	Architect	Avanto	Premier	Vida	TrioTim	Symphony
T1WI	TR	420–682	550	369	550	564	541–651	420
	TE	8.2–12	7.8	9.1	6.9	8.2	9.4	8.7
	ST	4 (ax) 2 (co)	4 (ax) 2 (co)	5	4 (ax) 2 (co)	4 (ax) 2 (co)	4 (ax) 2 (co)	4 (ax) 2 (co)
	FOV	200×200	200×200	180×180	200×200	200×200	200×200	180×180
	ETL	3	3	1	3	4	1 (pre), 3 (post)	1 (pre), 2 (post)
	Matrix	320×256	320×256	320×224	320×256	320×256	320×200	320×224
	NEX	1	1	1	1	1	1	2 (pre), 4 (post)
T2WI	TR	5,040–6,000	5,612	4,800–5,000	5,074	5,050	6,740	3,800–5,300
	TE	64-83	106	101-103	111	72	105	89-92
	ST	4 (ax) 2 (co)	4 (ax) 2 (co)	5	4 (ax) 2 (co)	4 (ax) 2 (co)	4 (ax) 2 (co)	4 (ax) 2 (co)
	FOV	200×200	200×200	180×180	200×200	200×200	200×200	200×200
	ETL	11-23	18	15	3	19	13	16
	Matrix	320×256	300×300	320×224	320×256	320×240	384×278	320×224
	NEX	1	1.5	2	1.6–2	1–3	1–4	3

T1WI: T1-weighted image, T2WI: T2-weighted image, TR: repetition time (msec), TE: echo-time (msec), ST: sice thickness (mm), FOV: field-of-view, ETL: echo train length, NEX: number of excitation, pre: pre-contrast, post: post-contrast.

patients showing no hyperostosis were included in the present study.

In all MR images, a convoluted cerebriform pattern (CCP) was defined as a mix of linear or curvilinear hyperintense and hypointense striations partially observed on the Gd-enhanced T1-weighted images (Gd-T1WI) and analyzed on MRI as an IP itself. On T2WI, the solid components of the tumor with or without partially or diffusely distributed hypointense striations, were considered as IP itself. The origin of IP was suspected at the sites where the enhancing mass was adherent on Gd-T1WI and at sites lacking a preserved peritumoral hyperintense layer adjacent to the tumor on T2WI. The preserved peritumoral hyperintense layer adjacent to the IP was interpreted as non-adherent sites on T2WI.

We analyzed the origin site of IP on Gd-T1WI and T2WI and defined positive as possibly distinguishing the origin and negative as impossibly distinguishing the origin of IP. The radiologic predictions were compared to the surgically confirmed origin sites. We analyzed the predictive accuracy of Gd-T1WI and T2WI separately and discussed causes of mis-localization.

Statistical analysis

Statistical analyses were performed to evaluate the association between MRI sequences the ability to predict the origin of inverted papilloma and surgically confirmed origin. Categorical variables were compared using the Pearson's chi-square test. A p-value of less than 0.05 was considered statistically significant. All statistical analyses were conducted using IBM SPSS Statistics (version 26.0; IBM, Armonk, NY, USA).

Results

Of the 51 cases, IP masses were located in the nasal cavity commonly (n=14), followed by maxillary sinus (n=12). Multi-sinus involvement including the nasal cavity was 25 cases. Of the 51 cases, surgically confirmed IP origin was in the maxillary sinus (n=16), frontal sinus (n=4), ethmoid sinus (n=14), sphenoid sinus (n=2) and nasal cavity (n=15). Compared to the surgically confirmed origin sites, T2WI was able to predict IP origin in 43 cases (43/51, 84.3%). Positive prediction of IP origin was 21 cases on Gd-T1WI (21/51, 41.2%). For comparison of IP origin prediction, the

predictive accuracy of T2WI was better in 22 cases (8 cases in the maxillary sinus, 6 cases in the ethmoid sinus and 8 cases in the nasal cavity) and similar in 21 cases (8 cases in the maxillary sinus, 4 cases in the frontal sinus, 6 cases in the ethmoid sinus and 3 cases in the nasal cavity) compared to that of Gd-T1WI. In 8 cases (2 cases in the sphenoid sinus, 2 cases in the ethmoid sinus and 4 cases in the nasal cavity), the prediction of IP origin was unable on Gd-T1WI nor T2WI (Table 3) (Figs. 1–4).

The origin of inverted papilloma was correctly predicted in 21 cases (41.2%) using Gd-T1WI and in 43 cases (84.3%) using T2WI. Comparison using the Pearson's chi-square test demonstrated a statistically significant difference between the two MRI sequences ($p<0.001$), indicating that T2WI showed superior performance in predicting the tumor origin. These findings indicate that T2WI provides significantly higher accuracy than Gd-T1WI in predicting the origin of inverted papilloma.

Table 3. Comparison of predictive accuracy for identifying the origin of Inverted papilloma between Gd-T1WI and T2WI based on surgical findings

	Gd-T1WI	T2WI	p-value
Correct*	21 (41.2%)	43 (84.3%)	
Incorrect†	30 (58.8%)	8 (15.7%)	<0.001
Total	51	51	

*MRI prediction of the origin of Inverted papilloma matched the surgically confirmed origin site.
†MRI prediction did not match the surgically confirmed origin site.
Gd-T1WI: Gd-enhanced T1-weighted images, T2WI: T2-weighted image.

Discussion

Although CT remains valuable for evaluating osseous structures and guiding surgical access, the reliance on CT alone may result in missed or inaccurately localized tumor origins, particularly in the absence of definitive hyperostotic changes. Hyperostosis, traditionally considered a hallmark of tumor attachment, was absent or located at non-origin sites in some cases, likely due to prior inflammation or remodeling changes.[5,6,8] In addition, diffuse sclerosis secondary to chronic sinusitis may obscure the site of origin, highlighting the limited specificity of CT findings within the complex sinonasal anatomy.[9]

According to the previous study,[8] CT-based detection of focal hyperostosis correlated with the surgically confirmed tumor origin in 89.1% of cases (49/55) among patients with focal hyperostosis on CT.

However, the overall incidence of focal hyperostosis in the patients with IP was only 63.2% and the most common site of tumor origin was the lateral nasal wall (52.6%). Therefore, not all patients with IP demonstrate focal hyperostosis on CT, making it difficult to determine the tumor origin in such cases. Furthermore, plaquelike or diffuse hyperostosis may occur irrespective of the tumor origin, and

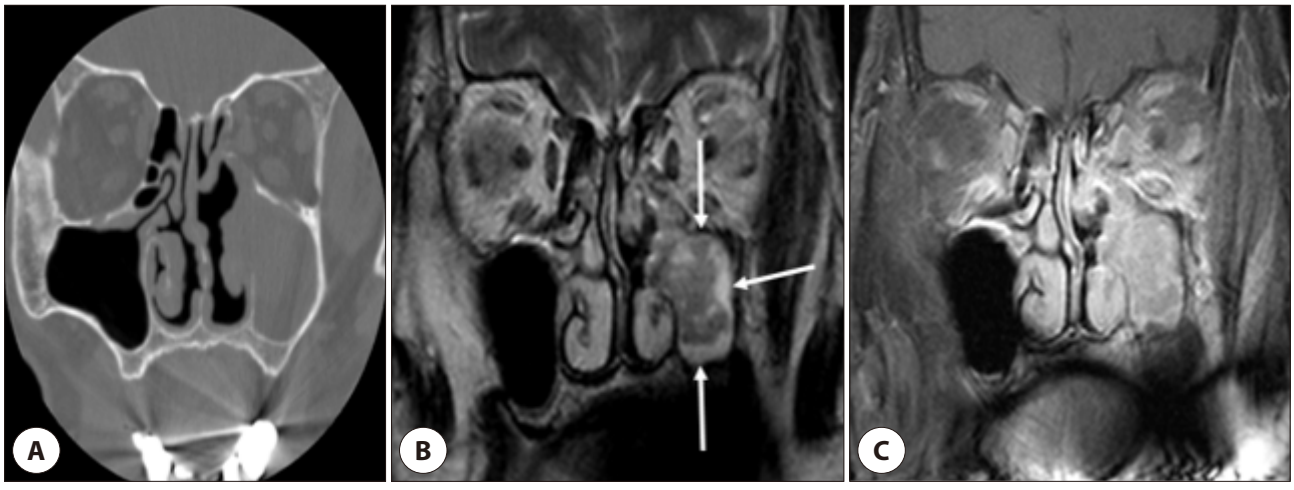

Fig. 1. A 64-year-old male with inverted papilloma originating from the medial wall of the maxillary sinus. On CT (A), sclerosis is not observed at the medial wall. On coronal T2WI (B), peritumoral hyperintense layers are evident at the inferior, lateral, and superior portions (arrows) of the mass but not at the medial wall. On Gd-T1WI (C), contrast enhancement is seen in both the mass and the peritumoral edematous mucosa, obscuring the mass origin. T2WI: T2-weighted image, Gd-T1WI: Gd-enhanced T1-weighted images.

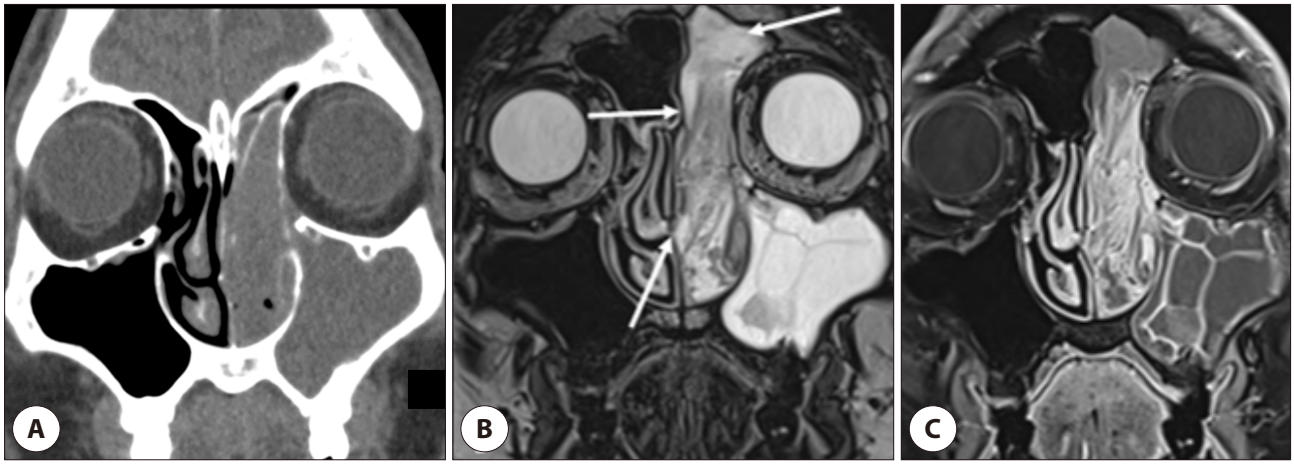

Fig. 2. A 57-year-old male with inverted papilloma originating from the lateral wall of the ethmoid sinus. On CT (A), sclerosis suggesting origin is not evident. T2WI (B) reveals peritumoral hyperintense layers at the inferior, medial and superior portions (arrows) of the mass but not at the lateral wall. Gd-T1WI (C) shows contrast enhancement in both the mass and peritumoral edematous mucosa, obscuring the mass origin. T2WI: T2-weighted image, Gd-T1WI: Gd-enhanced T1-weighted images.

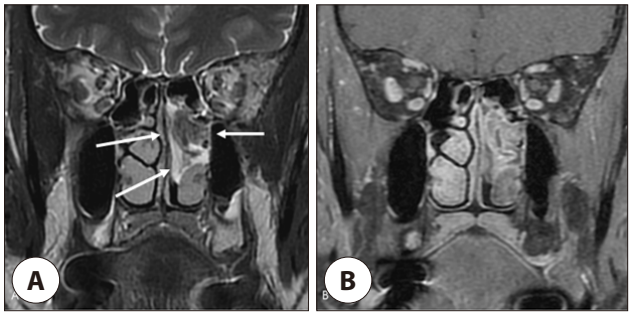

Fig. 3. A 66-year-old male with inverted papilloma originating at the inferior wall of the left ethmoid sinus. On coronal T2WI (A), peritumoral hyperintense layers are visible at the inferior, medial, and lateral portions of the mass (arrows), but not at the superior portion, i.e., the inferior wall of the ethmoid sinus. On Gd-T1WI (B), contrast enhancement is seen at both the mass and the peritumoral edematous mucosa, thus mass origin is obscured. T2WI: T2-weighted image, Gd-T1WI: Gd-enhanced T1-weighted images.

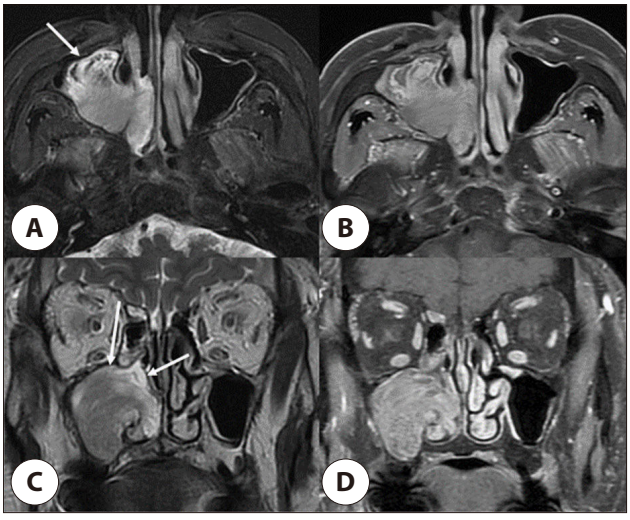

Fig. 4. A 67-year-old female with inverted papilloma originating from the posteroinferior wall of the left maxillary sinus. Axial (A) and Coronal (C) T2WI show peritumoral hyperintense layers at the anterior, superior, and medial portions (arrows) of the mass, but not at the posteroinferior portion of the maxillary sinus. Axial (B) and Coronal (D) Gd-T1WI demonstrate contrast enhancement in both the mass and peritumoral edematous mucosa, obscuring the mass origin. T2WI: T2-weighted image, Gd-T1WI: Gd-enhanced T1-weighted images.

diffuse sclerosis related to chronic sinusitis may further obscure the origin site.[8,9]

Preoperative imaging of the paranasal sinuses is essential for staging and treatment planning of sinonasal masses including the IP.[10–12] The presence of CPP on MR imaging may facilitate preoperative diagnosis and help guide therapeutic strategies, particularly in cases without focal hyperostosis on CT. In this study, we evaluated two MR imaging sequences, Gd-T1WI and T2WI for predicting the origin site of IP. MRI-based predictions were compared with surgically confirmed tumor origins. T2WI achieved a positive prediction rate of 84.3% (43/51), markedly outperforming Gd-T1WI, which identified the origin in only 41.2% (21/51) of cases.

The convoluted cerebriform pattern was described by Barnes et al. as a distinctive gross mucosal morphology of IP,[10,13] and on MRI it appears as characteristic alternating hypointense and hyperintense bands on T2WI and Gd-T1WI. Jeon et al.[13] reported that the CPP was observed on MRI in all IPs cases (100%) and that Gd-T1WI demonstrated a higher detection rate (93%) than T2Wis In contrast, our

study demonstrated superior visualization on T2WI. This discrepancy may be explained by the relatively frequent multisinus involvement in our cohort and the use of a 3T MRI scanner, which may enhance the visualization of signal intensity differences with the lesion. Additionally, the non-adherent portions of IP were more clearly demonstrated on T2WI, which helped to determine the tumor origin and guide surgical planning.

MRI also provided important diagnostic information in cases lacking hyperostosis on CT. In particular, the presence of a peripheral hyperintense layer on T2WIs, attributable to adjacent mucosal inflammation, often helped identify the tumor attachment site.[10,12,14] The similar findings were reported by Mohamed Eid et al.,[13] who demonstrated that T2WI was superior to Gd-T1WIs in 11 out of 16 cases. The difference may be explained by limited differential enhancement between epithelial and subepithelial tissues. Variations in cellularity and stromal composition within subepithelial tissues can result in variable contrast enhancement comparable to that of the epithelium. Furthermore, extrinsic factors, including variability in acquisition timing and dynamic contrast enhancement techniques, may further reduce the conspicuity of differential Gd enhancement.

Nevertheless, MRI was not infallible. In our study, eight cases were negative for the prediction of IP origin on T2WI, primarily due to the relatively large tumor size within the confined space of the nasal cavity or paranasal sinuses. In such cases, the intermediate signal intensity of the tumor filled the narrow sinonasal cavity and obscured the surrounding hyperintense peritumoral edema. In addition, 30 cases were negative for the prediction of IP origin on Gd-T1WI, largely due to difficulty in differentiating contrast enhancement of the mass itself from hypervascular enhancement of the surround mucosa. The most frequent factors limiting MRI localization included large tumor volume causing mass effect and multifocal tumor attachment, both of which have been previously reported as limitations of imaging-based localization.[5–7,10] One case (2.4%) originating from the medial maxillary wall was particularly challenging because of the complex adjacent soft tissue anatomy, and another case (2.4%) showed partial discordance between imaging and intraoperative findings, highlighting the need for cautious interpretation even with high-resolution MRI.

Complete surgical resection of IP is crucial to reduce the recurrence rates, which have been reported to range from 15% to 78%.[13] Preoperative evaluation with cross-sectional imaging, including CT and MRI, is therefore critical for determining the location and extent of the tumor and selecting the optimal surgical approach. In our study, MRI demonstrated superior performance compared with CT for identifying both the origin and extent of IP. The CPP on MRI and focal hyperostosis on CT remain important imaging findings for preoperative localization of tumor origin and extent. In particular, peritumoral high signal intensity on T2WI in maxillary sinus-reflecting non-adherent mucosal sites-helped guide surgical decision-making, such as choosing between ESS and Caldwell-Luc operation.

Although MRI serves as powerful adjunct in the preoperative evaluation of paranal sinus IP, particularly when CT findings are inconclusive without focal hyperostosis, integration of imaging findings with endoscopic evaluation and surgical experience remains essential for optimal patient outcomes.

The present study has several limitations. First, the relatively small sample size may have restricted the robustness of our findings. In particular, evaluating the tumor origin was challenging when the lesion was located in a small cavity such as the ethmoid sinus. A larger sample size would allow for more reliable assessment even in cases involving small anatomical spaces. Second, this study was conducted in a single institution, which may limit the generalizability of the results to broader populations. Third, the retrospective design inherently carries risks of selection and information bias. Future prospective studies are warranted to overcome these limitations and provide more definitive conclusions.

Conclusion

In cases where CT lacks definitive signs, such as focal hyperostosis, MRI provides critical complementary information for identifying the origin of IP with T2 hyperintense peritumoral changes. MR T2WI demonstrated significantly

greater accuracy than Gd-T1WI in localizing the tumor origin of the sinonasal IP. The hyperintense peritumoral edema on MR T2WI can improve preoperative surgical planning, increase the likelihood of complete tumor resection, and potentially reduce recurrence rates following ESS.

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Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

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Validation: Kim HJ.
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Writing - review & editing: Kim YW, Kim HJ, Cho KS.

Ethics Approval

This study was approved by the Institutional Review Board of our hospital (IRB No. 2506-015-152), and informed consent was waived due to the retrospective nature of this study.

References

1. Krouse JH. Development of a staging system for inverted papilloma. Laryngoscope 2000;110(6):965-8.
2. Lawson W, Schlecht NF, Brandwein-Gensler M. The role of the human papillomavirus in the pathogenesis of Schneiderian inverted papillomas. Head Neck Pathol 2008;2(2):49-59.
3. Busquets JM, Hwang PH. Endoscopic resection of sinonasal inverted papilloma: a meta-analysis. Otolaryngology – Head Neck Surg 2006;134(3):476-82.
4. Citardi MJ, Batra PS. Inverted papilloma: a 25-year experience. Otolaryngol Head Neck Surg 2007;136(5):626-38.
5. Han D, Wang C, Liu J, et al. Predicting the site of attachment of sinonasal inverted papilloma with computed tomography. Int Forum Allergy Rhinol 2012;2(4):388-92.
6. Chetrit A, Fliss DM, Margalit N, et al. Magnetic resonance imaging features of sinonasal inverted papilloma. Isr Med Assoc J 2007;9(12):847-50.
7. DelGaudio JM, Hudgins PA. Radiologic imaging in the management of inverted papilloma. Laryngoscope 2003;113(5):770-5.
8. Lee DK, Chung SK, Dhong HJ, Kim HY, Kim HJ, Bok KH. Focal hyperostosis on CT of sinonasal inverted papilloma as a predictor of tumor origin. AJNR Am J Neuroradiol 2007;28(4):618-21.
9. Woodruff WW, Vrabec DP. Inverted papilloma of the nasal vault and paranasal sinuses: spectrum of CT findings. AJR Am J Roentgenol 1994;162(2):419-23.
10. Jeon TY, Kim HJ, Chung SK, Dhong HJ, Kim HY, Yim YJ, et al. Sinonasal inverted papilloma: value of convoluted cerebriform pattern on MR imaging. AJNR Am J Neuroradiol 2008;29(8):1556-60.
11. Ojiri H, Ujita M, Tada S, Fukuda K. Potentially distinctive features of sinonasal inverted papilloma on MR imaging. AJR Am J Roentgenol 2000;175(2):465-8.
12. Eid M, Eissa L. Imaging of sino-nasal inverted papilloma: how can we emphasize the usefulness of the "striated pattern" sign? Egypt J Radiol Nucl Med 2020;51:29.
13. Yousem DM, Fellows DW, Kennedy DW, Bolger WE, Kashima H, Zinreich SJ. Inverted papilloma: evalua-

tion with MR imaging. Radiology 1992;185(2):501-5.
14. Chawla A, Shenoy J, Chokkappan K, Chung R. Imaging features of sinonasal inverted papilloma: a pictorial review. Curr Probl Diagn Radiol 2016;45(5):347-53.