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REVIEW

Laryngoscope Investigative Otolaryngology

Sinonasal lymphoma: A primer for otolaryngologists

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Abstract

Objective: Sinonasal lymphomas are a rare entity that commonly present with non-specific sinonasal symptoms and are often recognized immediately. Through this review, we aim to summarize important principles in diagnosis and treatment of sinonasal lymphomas, with the goal of disseminating the current knowledge of this under-recognized malignancy to otolaryngologists.

Methods: Systemic review using PRISMA guidelines of foundational scholarly articles, guidelines, and trials were reviewed focusing on clinical characteristics of key sinonasal lymphoma subtypes, along with available treatments in the otolaryngology, medical oncology, and radiation oncology literature.

Results: Sinonasal lymphoma are derived from clonal proliferation of lymphocytes at various stages of differentiation, of which diffuse large B-cell lymphoma (DLBCL) and extranodal natural killer/T-cell lymphoma (ENKTL) are the most common. Diagnosis and staging require biopsy with immunohistochemistry in conjunction with imaging and laboratory studies. Treatment is ever evolving and currently includes multi-agent chemotherapy and/or radiation therapy.

Conclusion: Otolaryngologists may be the first to recognize sinonasal lymphoma, which requires a comprehensive workup and a multidisciplinary team for treatment. Symptoms are nonspecific and similar to many sinonasal pathologies, and it is crucial for otolaryngologists to keep a broad differential.

Level of Evidence: 5

KEYWORDS
diffuse large B-cell lymphoma, extranodal NK/T-cell lymphoma, non-Hodgkin lymphoma, sinonasal lymphoma

1 | INTRODUCTION: AN OVERVIEW OF SINONASAL LYMPHOMA

Lymphoma is a hematologic malignancy which arises from clonal proliferation of lymphocytes at various stages of differentiation.[1] Extranodal involvement is commonly observed, including within the paranasal sinuses and nasal cavity. Sinonasal lymphoma, although a rare entity, comprises a notable portion of all sinonasal malignancies, second to epithelial malignancies, and is often first discovered by the otolaryngologist.[2] This is likely due to the focused head and neck exam as well as access to readily available diagnostic instruments including endoscopy. Due to subtleties at presentation with a lack of

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specific clinical signs, diagnosis can be delayed, which may worsen prognosis. Once the diagnosis is established, the role of the otolaryngologist is limited as treatment is largely nonsurgical; as such, the primary role of the otolaryngologist in sinonasal lymphoma is diagnosis and post-treatment surveillance. Given its capacity for being under-recognized, there is value in reminding otolaryngologists to be vigilant about this condition and to maintain an appropriate level of suspicion for lymphoma when evaluating patients with sinonasal pathology.

We reviewed the pertinent English literature with a focus on the clinical characteristics of key sinonasal lymphoma subtypes, along with available treatments using the PubMed and MEDLINE databases from inception of databases to June 17, 2022. The search included keywords for the following concepts: *non-Hodgkin lymphoma*, *diffuse large B-cell lymphoma*, *extranodal natural killer/T-cell lymphoma*, *sinonasal lymphoma*. Search terms were abbreviated and combined, and synonyms were used to ensure adequate review of the literature. A wide array of articles were identified, including basic science and clinical studies, case series, reviews, and guidelines. The references of these articles were then reviewed to identify additional sources not captured by the search databases. This study was conducted in agreement with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Figure 1).[3] This review provides a focused and practical overview of sinonasal lymphoma with the goal of highlighting the importance of this malignancy as it pertains to otolaryngologic practice. Practical recommendations regarding workup and treatment will be presented.

2 | EPIDEMIOLOGY

Primary malignancy within the sinonasal tract is exceptionally rare, accounting for 0.2% of invasive cancers and 3% of all head and neck cancers.[4] Lymphomas comprise between 3% and 5% of all cancers diagnosed each year with only a small subset presenting within the sinonasal tract with a reported incidence of 1.5% of all lymphomas.[5–10] Conversely, lymphomas account for 11% of all sinonasal cancers.[4,11] Extranodal lymphoma is dichotomized as either non-Hodgkin (NHL) or Hodgkin's lymphoma (HL), with nearly 90% classified as NHL.[7,9,12,13] HL is a specific histologic diagnosis and extremely rare in the nasal cavity and the paranasal sinuses with only a few case series in the English literature reported in the last four decades, whereas NHL comprises a majority of cases.[6,8,14–23] Therefore, the focus of this review will be on the sinonasal NHL (SN-NHL) subtypes.

The World Health Organization describes over 60 distinct NHL subtypes, of which 85%–90% arise from mature B lymphocytes and the remainder arise from mature T or natural killer (NKT) lymphocytes.[9,24–27] Within the paranasal sinuses and nasal cavity, B-cell lymphomas carry a more favorable diagnosis, whereas NK/T cell lymphomas are traditionally associated with a rapid, deleterious

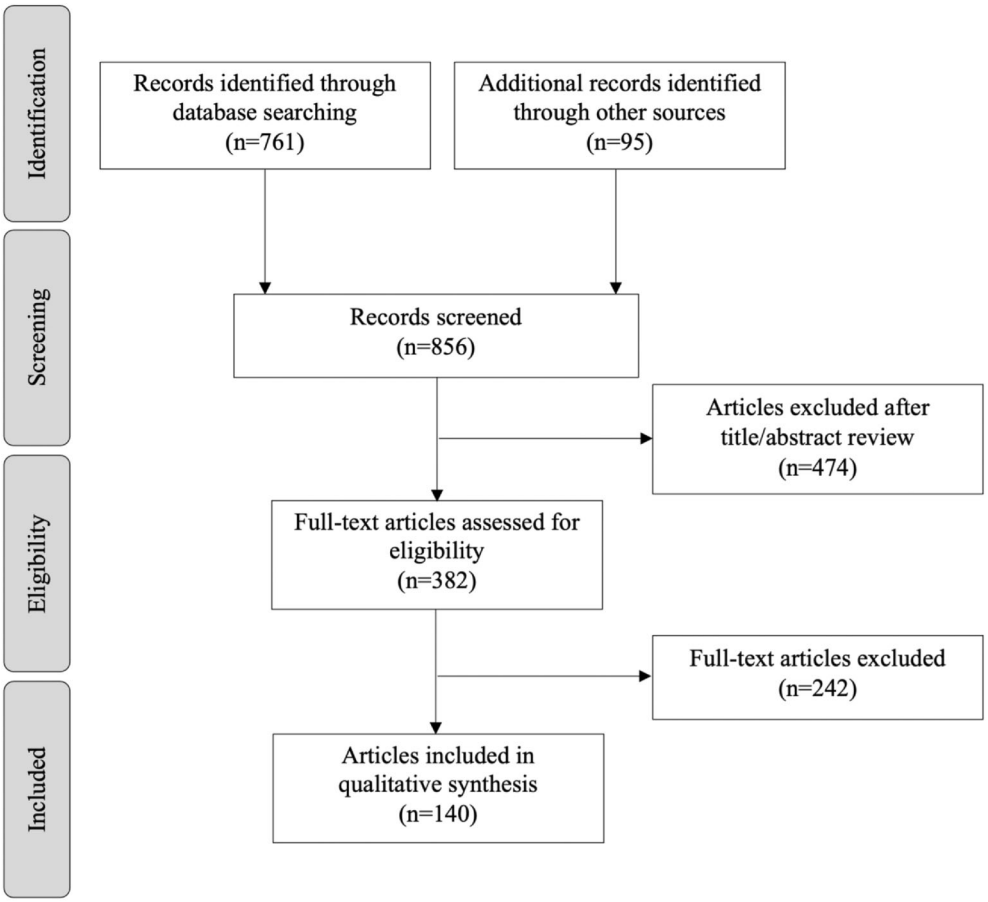

FIGURE 1 Preferred reporting items for systematic reviews and meta-analysis (PRISMA) flow diagram of study selection

clinical course.[4] The two most common SN-NHL include diffuse large B-cell lymphoma (DLBCL), followed by extranodal natural killer/T-cell lymphoma, nasal type (ENKTL). There are marked differences among the lymphomas given biologic heterogeneity in regard to epidemiology and presentation. Imaging and laboratory workup as well as histopathologic evaluation in conjunction with immunohistochemistry, which determines phenotype, antibody expression, and proliferation index, are critical in differentiating sinonasal lymphomas and ultimately dictate prognosis and treatment.[11]

DLBCL is the most common NHL and accounts for nearly 40% of new cases of lymphoma.[28,29] It is also the most frequently diagnosed high-grade, nonepithelial tumor of the paranasal sinuses and nasal cavity.[30] Recent Surveillance, Epidemiology, and End Results (SEER) database studies demonstrated the incidence of sinonasal DLBCL (SN-DLBCL) to be between 0.06 and 0.10 in 100,000.[31,32] It has a male predilection, occurs most commonly in the sixth to eight decade of life, and affects the Caucasian population more than any other race.[24,31,33–35] Although SN-DLBCL affects an older population, it has better 1-, 5-, and 10-year OS than SN-ENKTL, which were reported to be 87.5%, 69.9%, and 51.2%, respectively, with an average OS time of 10.5 years.[32,36] The most common site of involvement within the sinonasal cavity overall is the maxillary sinus, followed by the nasal cavity, and is commonly associated with orbital extension and ocular symptoms.[24,29,31,35,37] The maxillary sinus is the most common primary site in the Caucasian and African-American populations and nasal cavity is most common in the Asian/Pacific Island population.[2,35]

Historically known as lethal midline granuloma, sinonasal ENKTL (SN-ENKTL) is the second most common SN-NHL and most frequently involves the nasal cavity.[2,38] It is most often due to malignant transformation of NK-cells rather than transformation of cytotoxic T-cells and is characterized by progressive necrotizing local destruction of bone, soft tissue, and cartilage.[39,40] SN-ENKTL is most prevalent in Asia, Mexico, and Central and South America, where it is estimated to account for 3%–10% of all lymphomas whereas there is less than 1% prevalence in western countries.[39–47] A recent SEER database study showed a specific incidence rate for SN-ENKTL to be 0.032 per 100,000 with an annual increase in incidence of 9%.[32] There is a 3:1 male: female predominance and presentation occurs in the fifth and sixth decades of life.[35,48,49] Overall prognosis is poor with reported 1-, 5-, and 10-year OS of 68.6%, 53.2%, and 45.9%, respectively, with a median OS time of 6.73 years.[32,41,50–52] SN-ENKTL cases are uniformly positive for Epstein–Barr virus (EBV), suggesting its role in SN-ENKTL pathogenesis.[53–56] EBV may also play a role in some cases of SN-DLBCL.[53]

3 | CLINICAL PRESENTATION

Sinonasal lymphomas present with vague symptoms or concurrently with systemic disease. Unfortunately, as with most sinonasal primary tumors, early diagnosis is often difficult given sinonasal lymphomas expand within a confined anatomic space such as the air-filled sinus, nasal cavity, or nasopharynx, and do not cause symptoms until later in the disease process. SN-DLBCL has a predilection for the paranasal sinuses (Figures 2 and 3) and only after extension into surrounding structures are symptoms present, resulting in in locally advanced

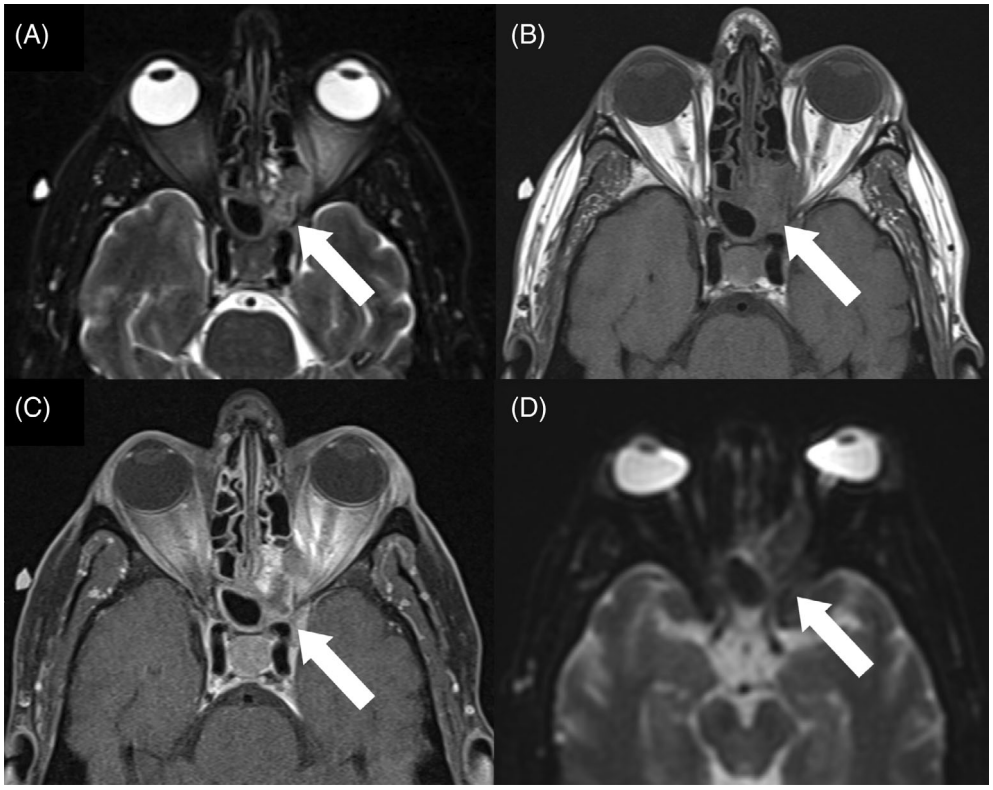

FIGURE 2 A 64-year-old male presenting with vision loss and ophthalmoplegia, found to have SN-DLBCL involving the left orbital apex. (A) Axial T1-weighted, (B) axial T2-weighted, and (C) axial T1-weighted post-contrast images demonstrating a left posterior ethmoid and sphenoid sinus mass extending into the left orbital apex (white arrow) resulting in vision loss. (D) Axial MRI diffusion-weighted imaging showing low signal

disease at the time of diagnosis.[57] SN-ENKTL is often located in the midline nasal cavity (Figures 4 and 5) and can cause nasal symptoms earlier, prompting more timely diagnosis. The most common presenting symptom is nasal obstruction with associated neck mass.[4,11,30,57,58] Recent imaging studies found regional lymphadenopathy to be present in 7%–19% of cases with SN-NHL.[59,60] Other reported symptoms include cranial neuropathies, non-healing ulcer, epiphora, headache, facial/nasal pain, and epistaxis although these are more commonly associated with advanced disease.[8,29,34,58,61] Many of these symptoms are commonly associated with benign conditions such as allergic rhinitis and upper respiratory infections and are often initially treated as such. Additionally, there are observed differences between B-cell and T-cell lymphomas. Advanced B-cell lymphomas may show soft tissue or osseous destruction, particularly of the orbit with associated proptosis (Figures 2 and 3), whereas advanced T-cell lymphomas are associated with septal perforation and destruction.[34,62] B symptoms (fever, weight loss, night sweats) are not typically found in localized SN-DLBCL but are more commonly seen in SN-ENKTL.[58]

On nasal endoscopy, the classic appearance of SN-NHL is a nonspecific soft tissue mass that is usually submucosal and nonulcerative with a polypoid or granuloma-like appearance (Figures 6 and 7).[2,57,63] They may be masked by overlying inflammation given frequent coexistence of rhinosinusitis as well as necrosis due to surrounding tissue destruction. Reports suggest one in three cases of SN-ENKTL seems to have a visible mass on nasal endoscopy, which is consistent with imaging findings, and more often reveal erosion, severe crusting, friability with bleeding to touch, and granulation (Figure 8).[38,64]

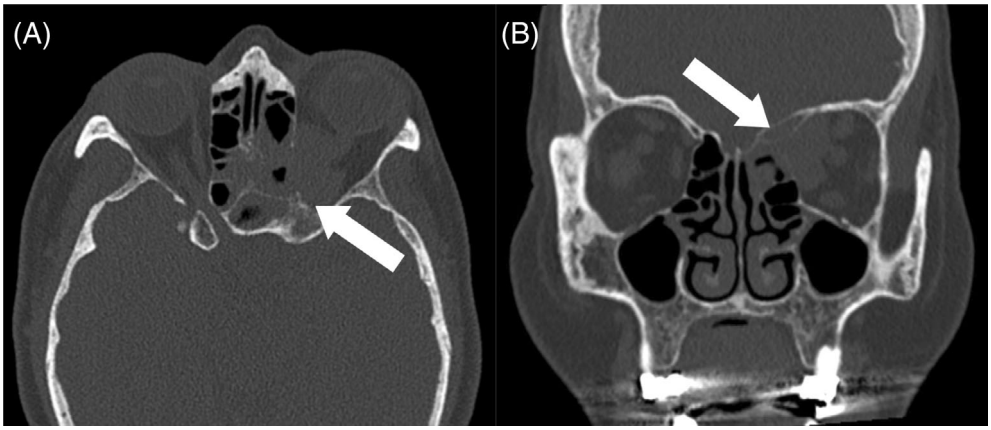

FIGURE 3 A 61-year-old female presenting with progressive left sided eye pain, headache, and vision changes diagnosed with DLBCL. (A) Axial and (B) coronal CT sinus without contrast demonstrating left anterior skull base mass (white arrow) extending into the orbit with bony erosion

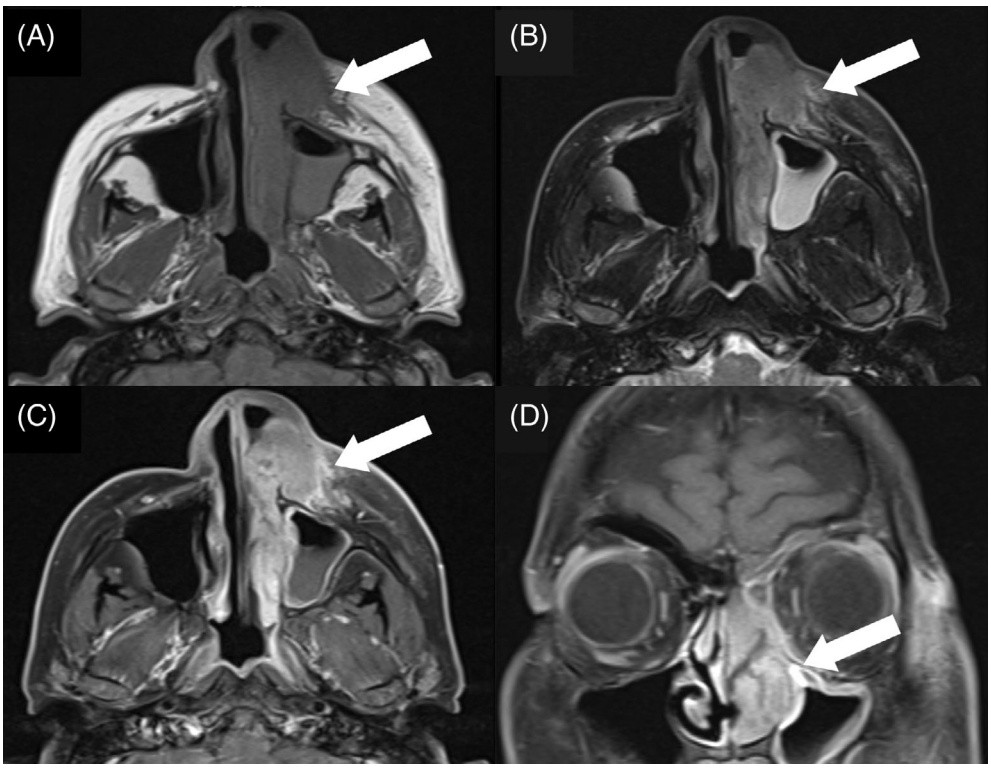

FIGURE 4 A 47-year-old female presenting with painless left-sided nasal and facial subcutaneous mass found to have SN-ENKTL. (A) Axial T1-weighted, (B) axial T2-weighted, and (C) axial and (D) coronal T1-weighted post-contrast with a left nasal cavity mass involving the soft tissues of the nose, left inferior and middle turbinates, left nasolacrimal duct and left inferomedial orbit (white arrow)

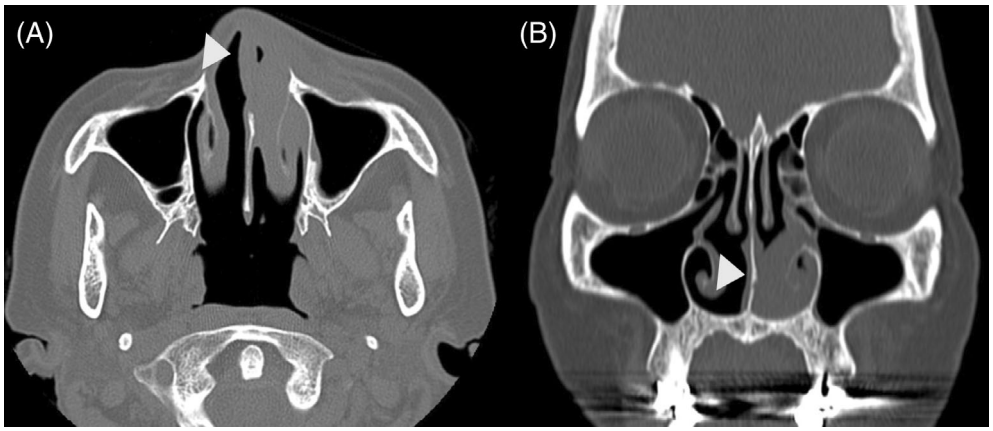

FIGURE 5 A 67-year-old female presenting with left nasal swelling with associated epistaxis and anterior drainage diagnosed with SN-NKTL. (A) Axial and (B) coronal CT sinus without contrast demonstrating a soft tissue mass (yellow arrowhead) filling left anterior nasal cavity and obliterating the inferior meatus without evidence of bony erosion or mucosal thickening within the sinuses

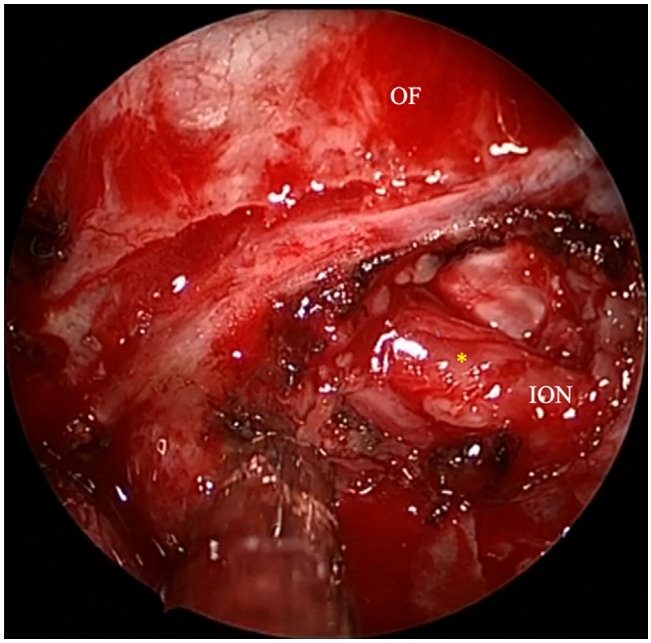

FIGURE 6 Left pterygopalatine fossa dissection demonstrating gray, rubbery mass (yellow asterisk) infiltrating infraorbital nerve (ION), confirmed to by recurrent SN-DLBCL. OF, orbital floor

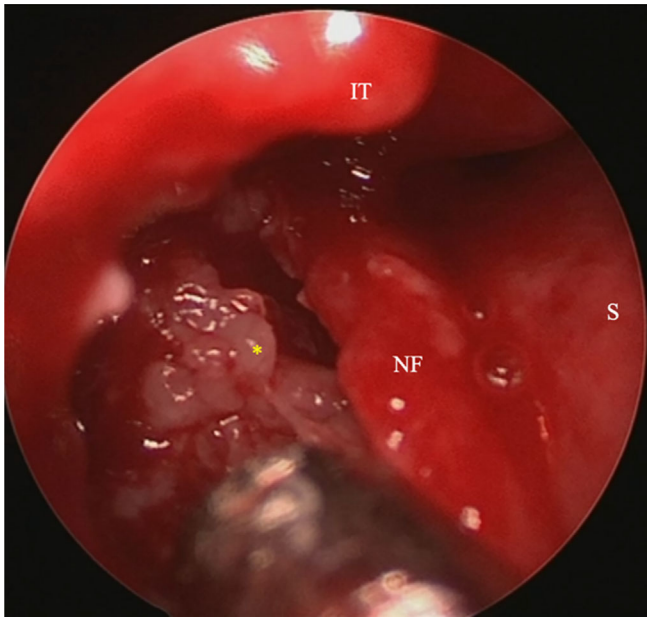

FIGURE 7 Poorly defined, infiltrative submucosal right nasal mass (yellow asterisk) with bony erosion filling anterior inferior meatus, confirmed to be DLBCL. IT, inferior turbinate; NF, nasal floor; S, septum

Therefore, superficial sampling may be non-diagnostic due to deeper underlying malignant lymphoma.[63,65] Additionally, nasal endoscopy findings may be nonspecific and may overlap other sinonasal pathologies including localized anti-neutrophil cytoplasmic antibody (ANCA)-negative destructive granulomatosis with polyangiitis (GPA), as well as entities such as localized invasive fungal sinusitis or cocaine-induced midline destruction. Deep tissue biopsies are paramount to distinguish between these. Repeated biopsies may be necessary to obtain adequate tissue for diagnosis and is performed by the otolaryngologist either in the clinic or under general anesthesia. More extensive surgeries including directed endoscopic sinus surgery, inferior turbinate resection, or Caldwell-Luc techniques have been shown to be superior compared to simple punch biopsy for obtaining adequate amounts of tissue in most patients. Sampled tissue should be sent for "fresh" (non-fixated) analysis as flow cytometry can be helpful in lymphoma diagnosis. After diagnosis is confirmed, referral to a medical oncologist is paramount and shown to improve the prognosis if completed early in the disease process.[66]

4 | HISTOLOGY, IMMUNOHISTOCHEMISTRY, AND LABORATORY STUDIES

On histology, DLBCL is characterized by a diffuse pattern of monomorphic infiltrates of atypical lymphocytes that are larger than the nuclei of benign histiocytes in the same tissue section (Figure 9A). They typically have little cytoplasm with cleaved or angulated nuclei.[63,67] The cells tend to surround and compress blood vessels rather than invade them, resulting in limited necrosis. Multiple variants

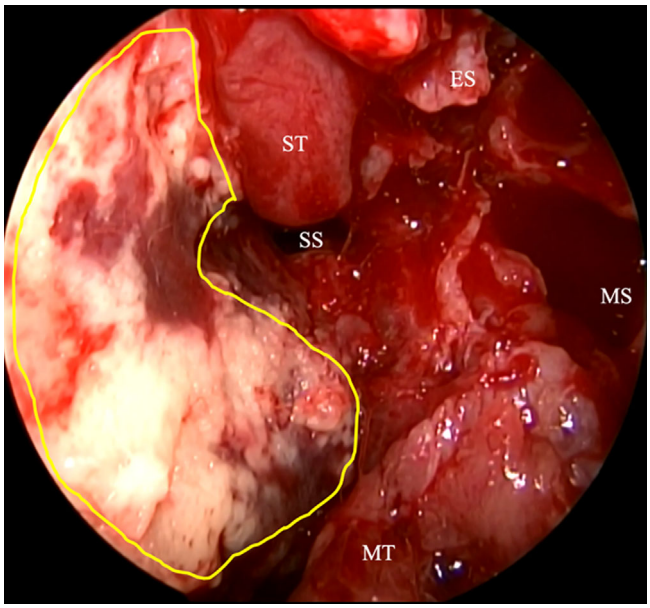

FIGURE 8 A patch of left posterior septal necrosis with mass infiltration (yellow outline), confirmed to be ENKTL. ES, ethmoid sinus; MS, maxillary sinus; MT, middle turbinate; SS, sphenoid sinus; ST, superior turbinate

of DLBCL have been described in the literature, of which centroblastic, immunoblastic, and anaplastic variants are most common.[67] Histologic features of ENKTL consist of a polymorphous infiltrate scattered among benign inflammatory cells and display angiocentricity and angioinvasion (Figure 10A). In contrast to DLBCL, ENKTL causes destruction of blood vessel walls due to tumor cell infiltration resulting in variable degree of localized necrosis.[63]

Lymphoma phenotypes can be determined by immunohistochemistry or by flow cytometry and determine potential targets for chemoimmunotherapy agents. Antigens typically present on both normal and malignant B-cells include CD19 and CD20. CD20 is of particular interest as it is expressed on over 90% of B-cell lymphomas and is the target of the monoclonal antibody rituximab that is typically included in the treatment regimen (Figure 9B).[5] SN-DLBCL are consistently negative for T-cell antigens such as CD3, CD4, and CD8. Additionally, B-cells can be distinguished from other cells with the presence of transcription factors including BCL6, PAX5, BOB.1, and OCT2 (Figure 9C) as well as surface or cytoplasmic immunoglobulins, including IgM followed by IgG and IgA.[67–69] ENKTL tumor cells are typically positive for CD2, CD3, CD7, and C56 (Figure 10B) and negative for CD20 or are CD56 negative but positive for cytotoxic granule proteins including TIA-1, granzyme B, and perforin (Figure 10B).[4,33,70–72]

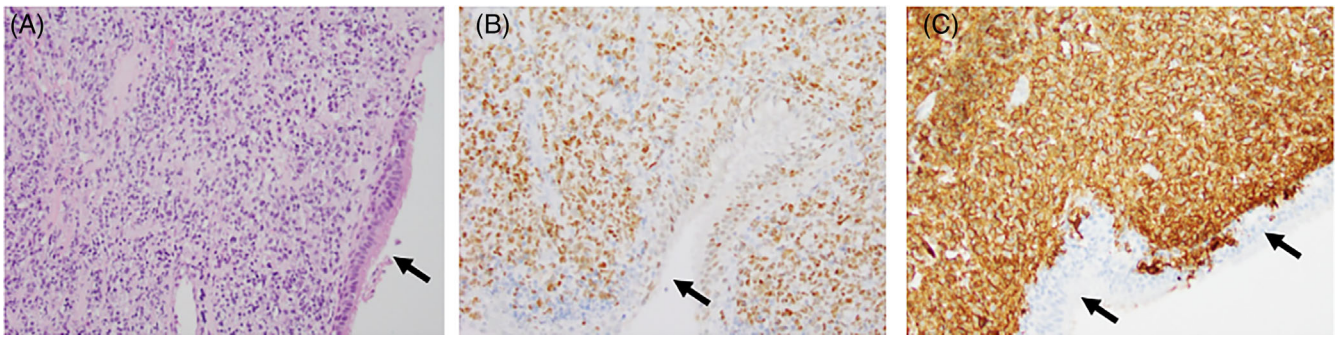

FIGURE 9 Sections of left nasal mass showing nasal mucosa (arrow) composed of atypical lymphocytes (A); immunostaining with B-lymphocytes positive for CD20 (B), and BCL6 (C)

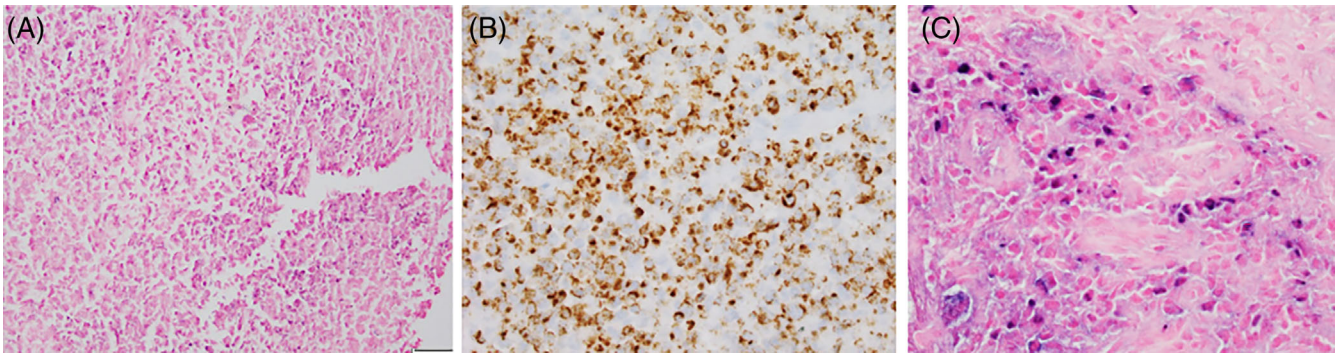

FIGURE 10 Sections of left nasal cavity mass showing diffusely necrotic proliferation of atypical lymphoid cells (A); those tumor cells with NK T-lymphocytes positive for CD2, CD7 and TIA-1(B); all neoplastic cells are positive for EBER (C)

As previously mentioned, SN-ENKTL is invariably positive for EBV by Epstein–Barr virus encoded RNAs (EBER) in-situ hybridization (Figure 10C).[53–56,70,71] Circulating EBV-DNA levels can also be used to monitor disease status and predict prognosis.[51,73–77] Elevated serum lactate dehydrogenase (LDH), commonly used as a prognostic factor in lymphoma, has been observed in several recent studies evaluating clinicopathologic features and associated prognosis in SN-DLBCL and SN-ENKTL. Prognosis was worse for patients with elevated LDH in both subtypes, though sample sizes were relatively small, warranting further investigation.[32,78–80]

5 | IMAGING

Biopsies are critical in establishing the diagnosis of SN-NHL; however, magnetic resonance imaging (MRI), computed tomography (CT), and positron emission tomography (PET)/CT can determine the extent of the lesion as well as assist in early detection and ultimately establish disease staging.[2,81] Staging is used to determine pretreatment risk stratification and selection of therapy. CT best evaluates bony involvement and is typically the first imaging modality obtained; MRI aids in visualization of soft tissue; and PET/CT is recommended for extraprimary regional and distant spread. Unfortunately, image findings are often nonspecific, making it difficult to distinguish between different sinonasal neoplasms by imaging alone. Although CT is often used as the preferred and routine examination method for sinonasal masses, MRI has been shown to be superior to CT for lymphoma workup, which often presents as a mass with soft tissue attenuation.[2,59,82–85] Although not reliably observed, SN-NHLs often demonstrate an intermediate signal intensity on T1-weighted images (Figures 2A and 4A) and variable intensity on T2-weighted images without fat saturation (Figures 2B and 4B).[2,60,83,86] T2-weighted images have been shown to help distinguish tumor from normal mucosa or fluid, a notable advantage over CT.[57,84] After contrast administration, SN-NHL homogenously enhances consistently in the literature (Figures 2C and 4C).[60,83–85] Contrast administration may also distinguish between lymphoma recurrence and scar tissue after treatment given scar tissue does not enhance with contrast.[83] When compared to squamous cell carcinoma (SCC), however, there is no significant difference in the degree of enhancement. Both MRI and CT show higher tumor homogeneity in NHL when compared to SCC.[60]

CT is the best technique to evaluate bone; however, MRI can assess the presence of bone destruction while also detecting intracranial tumor extension.[83] Bone destruction and invasion of adjacent structures may be observed in SN-NHL with lytic or permeative bone destruction and bone remodeling on imaging (Figure 3B).[11,59,82–84,87] In a study by Nakamura et al., 100% of SN-NHL patients with paranasal cavity involvement and 54% of patients with nasal cavity involvement had bone destruction.[82] Other MRI studies have found destruction of adjacent bone in 17%–38%.[59,60,88] Similar findings have been observed with CT scans with a reported 17%–31% of cases demonstrating osseous destruction.[38,60] When compared to SCC, a destructive growth pattern was significantly less common in SN-NHL.[88] Han et al. suggests lymphoma should be suspected with MRI findings demonstrating a permeative lesion of the skull base, invasion of the cavernous sinus without arterial narrowing, infiltration along the dural surface, and an iso- or hypointensity on T2-weighted imaging.[89] Considering that SN-NHL is fluorodeoxy-glucose (FDG)-avid, whole-body PET/CT is the most suitable imaging modality to determine other areas of involvement for staging.[40]

Distinguishing between the two most common SN-NHLs, DLBCL and ENKTL, with imaging remains a challenge, though there have been recent developments. Using conventional MRI, Chen et al. found SN-ENKTL was more often located in the nasal cavity, with ill-defined margins, heterogeneous signal intensity, internal necrosis, and marked enhancement (Figure 4).[90] SN-DLBCL was more often located in the paranasal sinuses with intracranial or orbital involvement, with homogenous intensity and mild enhancement (Figure 2A-C).[90] On CT, SN-ENKTL presents as a unilateral mass, is nonenhancing, and appears homogenous without central necrosis (Figure 4).[38] Additionally, the presence of mucosal thickening in the nasal cavity without sinus wall thickening should be considered suspicious for SN-NKTL (Figure 5).[91] Calculating apparent diffusion coefficient (ADC) following MRI with diffusion-weighted imaging (DWI), distinguishing between DLBCL and ENKTL has become clearer. This technique, which reflects the motion of water in soft tissues, was originally used to differentiate malignant from benign sinonasal tumors.[60,88,92–95] ADC values are typically lower in malignancies in comparison to benign skull base tumors and have been shown to be significantly lower in SN-NHL than in sinonasal carcinomas (Figure 2D).[81,88,96,97] Wang et al. compared ADC values between DLBCL and ENKTL using a higher resolution DWI technique and found the mean ADC value of ENKTLs to be significantly higher than that of DLBCLs. This is consistent with the study of He et al. who used a variation of the higher resolution DWI technique.[2,96]

6 | TREATMENT

Treatment for SN-NHL is dependent upon the subtype as well as the stage. The Ann Arbor Staging System was originally used for anatomic staging of both HL and NHL, but it does not subdivide subtypes of SN-NHL in a clinically relevant way.[98,99] Modifications to the Ann Arbor Staging System eventually resulted in the Lugano staging classification which was recently adopted by the NCCN NHL guidelines (Table 1).[100–102] This staging is further substaged by the presence or absence of systemic symptoms and extranodal status. Prognosis depends on the initial stage of the disease.[72] Treatment typically includes single- or multi-modality use of chemotherapy and/or radiation therapy.[31,39,58] Surgery is typically not indicated in the treatment plan aside from biopsy as a means of diagnosis.[32,103] An exception to nonsurgical management is observed in a rare sinonasal clonal plasma cell malignancy, sinonasal extramedullary plasmacytoma (SN-EMP). Although not classified as a SN-NHL subtype, SN-EMP develops from B-cell differentiation into plasma cells with derangements in plasmacytic differentiation. Recent studies have demonstrated improved survival with surgical resection of solitary lesions of SN-EMP in

TABLE 1 Lugano staging system[101]

Stage	Involvement	Extranodal status
Limited		
I	One node or a group of adjacent nodes	Single extranodal lesion without nodal involvement
II	Two or more nodal groups on the same side of the diaphragm	Stage I or II by nodal extent with limited contiguous extranodal involvement
II Bulky	Stage II but with "Bulky disease" ≥10 cm	Not applicable
Advanced		
III	Multiple lymph nodes on both sides of the diaphragm or nodes above the diaphragm with spleen involvement	Not applicable
IV	Diffuse or disseminated involvement of 1 or more extranodal organs or tissue beyond that designated "E," with or without associated lymph node involvement.	Not applicable

Note: Additional substaging variables include: A: asymptomatic. B: B symptoms—systemic symptoms of significant unexplained fever, night sweats, or unexplained weight loss exceeding 10% of body weight during the 6 months prior to diagnosis. E: extranodal status—involvement of a single, extranodal site, contiguous or proximal to a known nodal site (stages I to III only; additional extranodal involvement is stage IV).

conjunction with radiation therapy compared to single modality or non-surgical therapies.[104–107]

No consensus has been established on the optimal treatment plan for SN-DLBCL, though patients who receive chemoradiation demonstrate improved overall survival relative to patients who receive multi-agent chemotherapy or radiation alone.[24,36,108–110] Addition of immunotherapy may further enhance treatment regimens that already include multi-agent chemoradiotherapy with improved progression-free and overall survival.[24,36,111–113] Immunotherapy, also known as biological therapy, refers to treatment that stimulates the patient's immune system to target malignant cells. As it relates to lymphoma, this includes adoptive cell therapy, immunomodulators such as checkpoint inhibitors, and targeted antibodies.[114] This differs from chemotherapy in that chemotherapy is cytotoxic and disrupts cell function in rapidly growing and dividing cells. Rituximab, a chimeric monoclonal antibody against CD20, is typically in the chemotherapy regimen.[5] The current most common treatment for SN-DLBCL includes multi-agent chemoradiation that consists of rituximab, cyclophosphamide, doxorubicin, vincristine, and prednisone (R-CHOP).[39,90,115,116]

Traditionally, DLBCL has been treated with 6 cycles of R-CHOP. However, recent data support an abbreviated course of therapy (4 cycles) for those with limited stage disease. S1001 was a study of patients with early stage non-bulky DLBCL (<10 cm); 66% of the patients enrolled had only head and neck involvement.[117] After 3 cycles of R-CHOP, patients underwent an interval PET scan. If the interval PET was negative (i.e., Deauville scone of 1–3), patients received a fourth cycle of therapy, then stopped. Eighty-nine percent of patients enrolled had a negative interval PET. For the entire study population, 5-year progression-free survival (PFS) and overall survival (OS) were 87% and 89% respectively. This data supports that a majority of patients with DLBCL limited to the sinonasal area could be treated with 4 cycles of R-CHOP, reducing the risk of toxicity from either longer course of R-CHOP and/or the addition of radiation. Similar findings were observed in the FLYER trial which also supports treatment with 4 cycles of R-CHOP.[118] Options for relapsed/refractory disease are varied and depend upon the patient (age, co-morbidities) and timing of relapse. Radiation therapy may be an option if disease is limited, and the patient has not received radiation previously. If relapse within occurs 1 year of prior chemoimmunotherapy, CD19-targeted chimeric antigen receptor (CAR) T-cell therapy may be an option.[119,120] Other options include "salvage" chemo-immunotherapy and other targeted therapies, like the CD19 monoclonal antibody tafasitamab in combination with the immune modulatory drug lenalidomide.[121]

The relatively lower incidence of SN-ENKTL and variable relapse rate has made consensus treatment guidelines challenging.[51,74] Initial treatment for early stage disease typically includes local radiation therapy sequentially or "sandwiched" multi-agent chemotherapy with an average dose between 45 and 55 Gy.[122–128] The use of concurrent chemoradiation or chemotherapy with sandwiched radiation has shown improvement in prognosis and confers the best relative improvement in OS when compared to single modality therapy.[37,52,122,129–135] Newly diagnosed stage IV, relapsed, or refractory SN-ENKTL treated with conventional chemotherapy, however, is associated with poor survival.[123–126] Addition of L-asparaginase as well as autologous bone marrow/stem cell transplant has been described for advanced disease.[40,122,136] Recently, a regimen consisting of dexamethasone, methotrexate, ifosfamide, L-asparaginase, and etoposide (SMILE) with radiation therapy has shown to be effective for treatment of newly diagnosed stage IV, relapsed, or refractory SN-ENKTL.[129,137] Another regimen consisting of concurrent radiation and cisplatin followed by etoposide, ifosfamide, and cisplatin (VIPD) has also been suggested.[130] New treatment approaches continue to evolve as gene sequencing identifies mutated genes responsible for cell signaling pathways among other targets in SN-ENKTL which includes PD1 inhibitors, EBV targeted agents, and CAR T-cell therapy.[138,139]

7 | CONCLUSION AND PRACTICAL RECOMMENDATIONS

Despite playing a limited role in sinonasal lymphoma treatment, the otolaryngologist plays a paramount role in the diagnosis of sinonasal lymphoma. A high clinical suspicion is of critical importance and, once diagnosis is confirmed, patients require a comprehensive workup including physical exam, imaging, laboratory studies, and biopsy. While symptoms are similar to many sinonasal pathologies, it is

imperative to keep a broad differential in the workup of a sinonasal mass presenting with nonspecific, vague symptoms. Although there are no posttreatment surveillance protocols specific to sinonasal lymphoma, long-term follow-up with otolaryngology and oncology teams, and utilizing multimodal measures is recommended to evaluate for response and recurrence.[140,141] As for many tumors, the intensity of follow-up should be more frequent in the first 2–3 years when risk for disease recurrence is greatest.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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