Rwanda Medical Journal RMJ

ORIGINAL ARTICLE Open Access

Computed tomographic patterns of chronic rhinosinusitis in North-Eastern Nigeria

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ABSTRACT

INTRODUCTION: Chronic rhinosinusitis (CRS) is a major cause of inflammatory sinonasal diseases, resulting to frequent hospital visits. Computed tomography (CT) is essential in evaluation of CRS. The aim of this study was to determine the computed tomographic patterns of CRS in north-eastern Nigeria.

METHODS: This was a retrospective cross-sectional study of patients with CRS referred to the Radiology Department of our hospital for CT paranasal sinuses (PNS). The age, sex, and CT findings including involved sinuses, inflammatory patterns, CT Lund-Mackay (L-M) scores, and complications were obtained and recorded. Data were analyzed using IBM SPSS version 26.

RESULTS: A total of 142 patients with CRS had CT PNS. Most patients (63.4%) were males, with a mean age ± SD of 35.5 ± 14.7 years. The maxillary sinus was the most involved (84.5%). The sporadic pattern was the most frequent inflammatory pattern, 38.7% patients. The mean L-M score was 4.8 ± 5.3, and 36.4% patients had an L-M score of ≥4 (significance for CRS). The mean L-M score was higher in males and the association between the mean L-M score and sex was significant (p = < 0.001). Complications of CRS were noted in 39.4% of patients. Of which, sinonasal polyp was the most frequent one (28.2%). The association of complications of CRS and sex was significant (p = < 0.001), and CRS complications were mostly observed in males.

CONCLUSION: These insights highlight the importance of utilizing CT imaging for effective diagnosis of CRS and for ruling out its complications. The correlation of the L-M score with age and sex was negligible.

Keywords: Computed tomography, paranasal sinus, rhinosinusitis, inflammatory patterns.

INTRODUCTION

Chronic rhinosinusitis (CRS) is a long-standing inflammatory condition involving the nasal cavity and paranasal sinuses (PNS) that usually develops secondary to a prolonged or recurrent acute

***Corresponding author:** Dr. Umar Hassan Umar, umarhub@unimaid.edu.ng, +2348037614515; **Potential Conflicts of Interest (CoI):** All authors: no potential conflicts of interest disclosed; **Funding:** FAll authors. No external funding sought; **Academic Integrity.** All authors confirm that they have made substantial academic contributions to this manuscript as defined by the ICMJE; **Ethics of human subject participation:** The study was approved by the local Institutional Review Board. Informed consent was sought and gained where applicable; **Originality:** All authors: this manuscript is original has not been published elsewhere; **Review:** This manuscript was peer-reviewed by three reviewers in a double-blind review process.

Received: 17th February 2026; **Initial decision given:** 18th March 2026; **Revised manuscript received:** 13th April 2026; **Accepted:** 29th June 2026.

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Citation for this article: U. H. Umar; A. Adamu; D. M. Yunusa et al. Computed Tomographic Patterns of Chronic Rhinosinusitis in North-Eastern Nigeria. Rwanda Medical Journal, Vol. 83, no. 2, p. 18-27, 2026. https://dx.doi.org/10.4314/rmj.v83i2.4

infection [1]. It predominantly affects young and middle-aged adults and is clinically characterized by sinonasal inflammation lasting 12 weeks or more [1]. Aetiological factors for CRS include drainage obstruction from anatomical variants, sinonasal polyposis (SNP), chronic allergy and infections, and dental pathologies and procedures [1].

Computed tomography (CT) scan is a crucial tool in evaluating patients with CRS, due to its greater precision in demonstrating sinonasal anatomy and pathologies [2]. Diagnostic imaging is commonly used in cases of recurrent and complicated sinonasal diseases (SNDs), which may be serious if not promptly diagnosed and properly treated [3,4]. A CT scan is an important imaging modality in evaluating CRS for preoperative surgical planning to avoid surgical complications and postoperative follow-up. It also has high sensitivity and specificity in diagnosing inflammatory SNDs, especially CRS [5]. Plain radiography has limitations in evaluating patients with CRS because of the complex anatomy of the area. So, CT scan is regarded as the imaging modality of choice in the evaluation of CRS for diagnosis and its complications. CT evaluation for the severity of CRS is a strong predictor of treatment outcome [6].

Obstruction of the osteomeatal complex (OMC) is usually considered the underlying cause of most cases of sinusitis, because it may result in maxillary, anterior ethmoid, or frontal sinus diseases [4]. The five primary patterns of inflammatory SNDs classify these conditions into distinct anatomical or pathological categories, based on the affected drainage pathway. This classification aids surgeons in selecting the appropriate type of surgery needed for treatment [7,8]. Infundibular and OMC patterns were the most commonly observed inflammatory patterns of patients with CRS [7,9]. The Lund-Mackay (L-M) score is a CT-based scoring system for CRS, and it correlates well with the severity of the disease, the extent of surgery, treatment response, and complication rates [8,10]. It is popular due to its simplicity and good inter- and intra-observer reliability [8]. Functional endoscopic sinus surgery is the treatment of choice in patients with CRS, and the extent of the surgery is directly proportional to the L-M Score [11]. The CT L-M scoring system is considered the most reproducible, objective, and simple system in evaluating CRS [11]. CRS is associated with multiple complications or extensions to adjacent structures, which include intraorbital complications (orbital cellulitis, orbital abscess, etc.), usually from an ethmoid sinus infection, intracranial complications (meningitis, cavernous sinus thrombosis, and epidural, subdural, and brain abscesses), and intraosseous complications like osteomyelitis, especially involving the frontal bone [13-15].

This study aims to determine the CT patterns of patients with CRS in north-eastern Nigeria, especially highlighting the involved sinuses, inflammatory patterns, severity of CRS based on the L-M score, and the associated complications. The paucity of existing literature in our region is what gave motivation for this research.

METHODS

Research design, population, and setting

A hospital-based retrospective cross-sectional study of patients with the signs and symptoms of CRS was conducted from January 2020 to December 2024 at the Department of Radiology, University of Maiduguri Teaching Hospital (UMTH), Maiduguri, northeastern Nigeria. A convenience sampling method was used, where all consecutive patients referred to the Department for CT PNS during the study period were retrieved in the index study. The CT images were acquired using a 128-slice Siemens CT Scanner and a 64-slice Canon Aquilon CT scanner. The inclusion criteria included patients with clinical features of CRS that were refractory to medical treatment for ≥ 12 weeks. The exclusion criteria included patients with symptoms < 12 weeks and a history of sinonasal tumours, trauma, previous surgery, and incomplete information.

Ethical approval for the study was obtained from the Research and Ethics Committee of the UMTH, with approval number: OHRP-IRB-FWA-00013572 UMTH/REC/24/207.

Data collection

Axial CT images of the PNS with the patient lying supine were obtained from the hard palate to above the frontal sinus at 3.5 mm slice thickness without intravenous contrast, but contrast was only given if a sinonasal mass was observed. Images were then reformatted to thinner slices of coronal and sagittal planes. The CT images were retrieved from the departmental archives using the CT workstation and reviewed by experienced radiologists.

Data sources

Data collected comprised age, sex, involved sinuses, inflammatory patterns, L-M score, and

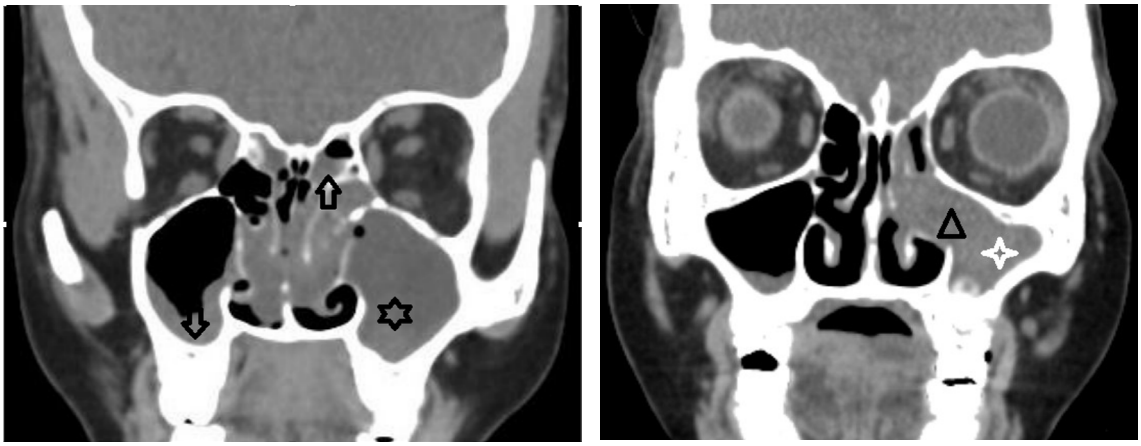

Figure 1: Coronal reformatted computed tomographic image of the paranasal sinuses

Left: *Obstruction of both osteomeatal complexes with complete opacification of the left maxillary sinus (star), partial opacification of ethmoid sinuses (up arrow) and nasal cavity, and mucosal thickening of the right maxillary sinus (down arrow).* ***Right:*** *soft tissue mass from the left maxillary sinus (star), which extends to the ipsilateral ethmoid sinus and nasal cavity with widening of the ipsilateral osteomeatal complex (triangle), and mucosal thickening at the right maxillary sinus.*

complications or associations of CRS. However, patients who did not fulfil the inclusion criteria were excluded from the study. CT scans were classified following the criteria by Sonkens et al. who recognized five radiological inflammatory patterns of the SNDs based on the drainage pathway affected [7]. These include infundibular pattern (I): isolated obstruction of maxillary sinus ostium and/or ethmoid infundibulum; OMC pattern (II): maxillary, ethmoid and frontal sinuses are affected, due obstruction of the OMC (Figure 1); sphenoethmoid recess (SER) pattern (III): inflammatory changes in the SER which obstruct the sphenoid sinus in isolation or conjunction with the posterior ethmoid air cells; sinonasal polyposis (SNP) pattern (IV): extensive polyps are seen in nasal cavity and the paranasal sinuses (Figure 1); and sporadic pattern (V): no specific pattern present with random mucosal thickening, polyp or retention cyst.

CT paranasal sinuses were scored using the L-M scoring system for CRS [10], where each sinus group (maxillary, anterior ethmoid, posterior ethmoid, frontal, and sphenoid sinus) was graded between 0 and 2, where 0 indicates no opacification, 1 indicates partial opacification, and 2 indicates complete opacification. The OMC obstruction is scored as 0 for no obstruction and 2 for obstruction. The scores from each side (left and right) are summed and range from 0 to 24. The mean L-M score of ≥ 4 was considered significant (diagnostic of CRS), which may require possible surgical intervention [16].

Data Analysis

The data obtained were recorded in a structured data collection sheet and analyzed using IBM SPSS Statistics for Windows® version 26 (IBM Corp., 2018, Chicago, IL, USA). Descriptive statistics were employed to analyze the obtained data, and results were presented as percentages, means, SD, medians, ratios, figures, and tables. The student's t-test for continuous and categorial variables, while the chi-square or Fisher's exact test for categorical variables, were employed to assess the associations, while Pearson correlation coefficient was used to assess the correlation between L-M score with sex and age, respectively. A p-value of < 0.05 was considered statistically significant at a 95% confidence interval.

RESULTS

A total of 142 patients with CRS who underwent CT scans of their PNS were included in this study. Among these, 90 patients (63.4%) were males, and 52 (36.6%) were females, resulting in a male-to-female ratio of 1.7: 1. The patients' ages ranged from 8 to 76 years, with a mean age ± SD of 35.5 ± 14.7 years. The modal age group was 31 - 40 years, accounting for 31 (22%) patients (Table 1). However, the relationship between the age group and sex was not statistically significant ($p = 0.165$). Regarding the CT patterns of CRS, the maxillary sinus was the most commonly involved, observed in 120 patients (84.5%), followed by the ethmoid sinus, seen in 84 (59.2%) patients. Then,

Table 1: Demographic Distribution of the Study Population

	Frequency (%)			
Age group (years)	**Male**	**Female**	**Total**	**p-value**
1-10	2(1.4)	0(0.0)	2(1.4)	
11-20	15(10.6)	12(8.5)	27(19.0)	
21-30	20(14.1)	10(7.0)	30(21.1)	
31-40	18(12.7)	13(9.2)	31(21.8)	
41-50	20(14.1)	12(8.5)	28(8.5)	
51-60	7(4.9)	9(6.3)	16(11.3)	
61-70	7(4.9)	0(0.0)	7(4.9)	
71-80	1(0.7)	0(0.0)	1(O.7)	
TOTAL	90(63.4)	52(36.6)	142(100.0)	0.165

frontal sinus involvement was noted in 32 (22.5%) patients, and the remaining 26 (18.3%) patients showed involvement of the sphenoid sinus. These patterns were more prevalent in males across all involved sinus subtypes. However, the relationship between the involved sinus and sex was not statistically significant (p = 0.702). One or more sinuses were involved in 137 (96.5%) patients, while the remaining 5 (3.5%) patients showed isolated rhinitis without coexisting sinusitis.

In terms of radiological inflammatory patterns, the sporadic pattern was the most common among patients with CRS, observed in 55 (38.7%) patients, followed by the OMC pattern seen in 41 (28.9%) patients (Table 2). Male patients were predominantly affected across all inflammatory patterns except the SER pattern. However, the association between inflammatory patterns and sex was also not statistically significant (p = 0.448). The total mean CT Lund-Mackay score was 4.8 ± 5.3, with a median score of 4.0 (Table 3).

The mean L-M score was higher in males (5.1 ± 5.5) than in females (4.4 ± 5.0), and the association between the mean L-M score and sex was statistically significant (p = < 0.001). Forty-six (32.4%) patients had a CT L-M score of ≥ 4 (which represent significant CRS). The correlation between CT L-M score with age and sex showed a negligible negative relationship and not statistically significant respectively (r = - 0.064, - 0.059, and p = 0.448, 0.431). In this study, complications or associations of CRS were observed in 56 (39.4%) patients, while the remaining 82 patients (60.6%) had none. However, no intracranial complication was recorded in this study. Sinonasal polyp/retention cyst was the most common complication of CRS, accounting for 40 (28.2%) patients. Then, a mucocoele followed it, which was recorded in 11(7.7%) patients (Table 4). Males dominated in most of the various complications of CRS, except orbital abscess, which had equal sex predilection as shown in Table 4. The association of complications of CRS and sex was statistically significant (p = < 0.001).

Table 2: Relationship of Inflammatory Pattern of the Study Population and Sex

	Frequency (%)			
Pattern	**Male**	**Female**	**Total**	**p-value**
Infundibular	14(9.9)	6(4.2)	20(14.1)	
Osteomeatal unit	29(20.4)	13(9.2)	41(28.9)	
SE recess	5(3.5)	8(5.6)	13(9.2)	
Sinonasal polyposis	10(7.0)	6(4.2)	16(11.3)	
Sporadic	34(23.9)	21(14.8)	55(38.7)	
Normal sinus	3(2.1)	2(1.4)	5(3.5)	0.448

*SE – Spheno-ethmoid. *Some patients had more than inflammatory pattern*

Table 3: Association of Computed Tomographic Lund-Mackay Score with Sex and Age

CT L-M Score	Male	Female	Total	r	p-value
Mean ± SD	5.1 ± 5.5	4.4 ± 5.0	4.8 ± 5.3		< 0.001*
Median	4.0	4.0	4.0		
Range	0- 24	0-21	0- 24		
Correlation					
Age	-	-	-	-0.064	0.448
Sex	-	-	-	-0.059	0.431
Score			**N (%)**		
< 4	-	-	96(67.6%)		
≥ 4	-	-	46 (32.4%)		

*L-M – Lund-Mackay Score, SD – Standard deviation, r – Pearson correlation coefficient, N – Frequency, *Significant*

Table 4: Relationship of Complications of Chronic Rhinosinusitis with Sex

	Frequency (%)			
Complication/Association	**Male**	**Female**	**Total**	**p-value**
Polyp/Retension cyst	25(17.6)	15(10.6)	40(28.2)	
Mucocoele	8(5.6)	3(4.0)	11(7.7)	
Intraorbital				
Orbital cellulitis	*2(1.4)*	*1(0.7)*	*3(2.1)*	
Orbital abscess	*1(0.7)*	*1(0.7)*	*2(1.4)*	
Intracranial lesion	0(0.0)	0(0.0)	0(0.0)	
Nil	54(38.0)	32(22.5)	86(60.6)	
Total	**90(63.4)**	**52(36.6)**	**142(100.0)**	**< 0.001***

**Significant*

DISCUSSION

CT scan is the optimal non-invasive diagnostic imaging modality for nasal and paranasal sinus diseases. It provides excellent delineation of the complex sinonasal anatomy, its variations, and the extent of sinus diseases. Additionally, it serves as a valuable guide during surgical operations, with CT images closely correlating with the surgical approach [4,9]. There were more males with CRS in this study, which agreed with the findings from similar studies reporting high male sex predilection [17,18]. However, other studies have reported a female preponderance [19-21]. The male-to-female ratio in this study was similar to that reported by Pandey et al. of 1.5:1 and Chauhan et al. of 1.7:1 [22,23]. The mean age and modal age group reported in the study were comparable to those reported in similar studies on CRS [9,18]. This demographic distribution is consistent with the global trend of CRS, which often shows a higher prevalence of males and adults in their middle-age [9,18]. However, the lack of statistical significance in the relationship between age group and sex (p = 0.165) in the index study suggests that CRS affects a broad demographic spectrum despite this trend. The maxillary sinus was the most involved one (84.5%), followed by the ethmoidal sinuses (59.2%) in this study. This was in agreement with the findings of similar studies, which reported that the maxillary sinus was the most involved sinus in patients with CRS [9,18,24]. Nair et al. also reported that the maxillary sinus was the most commonly involved (72.9%), followed by the ethmoid (65.8%), sphenoid (35%), and frontal sinuses (55%) [25]. Other previous studies reported slight variations to the above; Shah et al. reported that the maxillary sinus as the most commonly involved (91.1%), while the frontal sinus was the least involved [26]. Other studies have also reported that the anterior ethmoid was the commonly involved sinus, followed by the maxillary sinus [27,28]. These

findings disagreed with the records in this study. The predominance of maxillary sinus involvement aligns with the sinuses' anatomical structures and drainage pattern, where the maxillary sinus is predisposed to infection due to its prominent exposure to the environment, its high likelihood of getting obstructed, and poor drainage capabilities as secretion has to move against the gravity of the ostium above [9].

The maxillary sinus may be involved alone, as in infundibular or sporadic patterns, or in conjunction with other sinuses, as observed in OMC and SNP patterns. Multiple sinuses may be involved simultaneously, as evidenced by the involvement of one or more sinuses in 96.5% of cases in this study. A similar finding was observed with multiple sinus involvements by Altimimy et al. in their study [9]. Amodu et al. reported a CT pattern showing involvement of at least one PNS in 98.3% cases, which agreed with the finding in this study [18]. Nair et al. reported a statistically significant correlation between the extent of sinus involvement in CT scans, and the severity of symptoms [25]. The higher prevalence in males across all sinus subtypes, although not statistically significant ($p = 0.07$), may reflect the general trend of high prevalence of CRS in males, but may warrant further investigation to unravel the possible biological or environmental factors contributing to this trend.

The sporadic inflammatory pattern was the most prevalent among CRS patients (38.7%), in this study, followed by the OMC pattern (28.9%), with the least prevalent pattern being the SER pattern (9.2%). This contradicts the reports by Sonkens et al. and Al-Timimy et al., who documented that the infundibular pattern as the most common inflammatory pattern, followed by the OMC pattern, and the sporadic pattern, and the SER pattern as the least common [7,9]. While Rathor et al. reported the sinonasal polyposis pattern (58.9%) as the commonest, followed by the OMC and SER patterns, and the infundibular pattern (2.9%) was the least common and these reports were in disagreement with the findings in this study [29].

The infundibular pattern signifies inflammation limited to the osteomeatal unit, and the disease is confined to the maxillary sinus. This indicated that most of the patients in the previous studies by Sonkens et al. and Al-Timimy et al. have limited disease involving the maxillary sinus, while the other patterns indicated multiple sinus involvement, as seen in this study [7,9]. Factors like demographic differences, environmental factors, genetic differences, and variations in treatment approaches may contribute to the variations in the inflammatory patterns across these studies. In addition, variations in the criteria used for sinus involvement in the studies may also play a role, as evidenced by the addition of another group referred to as the special pattern, whose CT inflammatory pattern does not fit into the above, by Al-Timimy et al. [9], and the exclusion of the sporadic pattern of inflammation by Rathor et al. [28].

The L-M score is used to evaluate the severity of sinus involvement and staging of CRS based on CT scan findings. The mean L-M score for males was slightly higher than that of females in this study, indicating that males have more severe sinus involvement on average. In this study, the overall mean L-M score was 4.8, suggesting moderate sinus involvement. While a previous study in Sokoto, northwestern Nigeria showed a high mean L-M score of 9.8 ± 5.5 which disagreed with our finding which might be explained by different inclusion criteria used, where they included patients aged ≥ 16 years while we included all age groups [30]. In this study, the mean L-M score was higher in males than females (5.1 versus 4.4), and the association between mean L-M score and gender was statistically significant ($p = <0.001$). Similar findings (11.5 versus 8.1, and $p = 0.008$) were also reported by a previous study in Baghdad, Iraq [31]. They suggested that significant radiological evidence of SNDs should be considered when the score is 6 or higher. These findings were similar to the observation made in this study. However, Ashraf et al. found that the mean L-M score in patients undergoing imaging for non-rhinological symptoms was 4.3, which was similar to our finding [32]. However, Hopkins et al. reported that 21% of patients in their study underwent functional endoscopic sinus surgery despite having an L-M score of < 4 [33].

The index study showed that 32.4% of patients had an L-M score of ≥ 4. Bhattacharya et al. reported that an L-M score of ≥ 4 was considered positive (significant) for CRS in their study [16]. A similar study by Hirsch et al. also found that 28% of their study population with an L-M score of ≥ 4 exhibited symptoms of CRS, which was in concordance with our findings, while more than 40% had

no symptoms despite having such scores [34]. Additionally, 20% of those with current CRS had an L-M score of ≥ 4. This suggests that radiological inflammation does not always correlate with the presence of symptoms, and symptoms cannot always be directly attributed to sinus inflammation. Based on the L-M score reported in this study, most of our patients would benefit from functional endoscopic sinus surgery. However, Singh et al. reported a statistically significant improvement in symptoms in patients with a pre-operative L-M score of ≥13.1, and concluded that the extent of surgery is directly proportional to the L-M score; the higher the score, the more extensive the surgical intervention [11]. The overall severity of sinus involvement, as measured by the CT L-M score in this study, does not appear to be strongly influenced by age and sex (p-values of 0.448 and 0.431, respectively) [11]. This suggested that CRS severity is multifactorial and not solely dependent on these demographic variables. Factors such as environmental exposures, genetic predisposition, or underlying health conditions may play a more significant role in determining the severity of sinus involvement.

Complications of CRS were observed in 39.4% patients, while 60.6% of the patients had no complications in this study. While Tuladhar et al. observed complications in 21.1% patients which is low proportion than finding in this study [15]. Hopkins et al reported that the complication rate is directly proportional to L-M score of patients with CRS [13]. Retention cyst/polyp was regarded as a complication of rhinosinusitis in this study. Sinonasal polyps/retention cysts were most common complications, accounting for 28.2% of cases in this study. A previous study from Nepal recorded 29.4% of patients, which agreed with our finding, but they considered polyps as an incidental pathology, not a complication of CRS [15]. This indicates that about one-fourth of the patients had retention cysts or polyps, typically related to chronic inflammation and fluid accumulation in the sinus mucosa [14]. Retention cysts are commonly seen in the maxillary sinus and are found in up to 3.2-26% of imaging studies [35,36]. Polyps, like retention cysts, appear as smooth, outwardly convex soft tissue masses on CT scans, and differentiating them on imaging is difficult [14]. Mucocoele is a mucous-filled cyst lined with pseudostratified columnar epithelium and can arise as a complication of CRS, polyposis, FESS, or trauma [14]. Mucocoele cases were observed in 7.7% of patients in this study. Kandukuri et al. reported that mucocoele constituted 0.57% of sinonasal disease on CT scans [37], while Ogolodom et al. documented the incidence of mucocele in CT scans as 2.6% [38]. These findings showed low values compared to the index study. These cysts develop due to the obstruction of the sinus ostium and can gradually expand over time, and may extend into adjacent structures such as the orbital and cranial compartments. Most mucocoeles involve the frontal and ethmoid sinus, though not as common as polyps, their presence may lead to significant symptoms [37,38].

Orbital complications, including orbital cellulitis and orbital abscess, were relatively uncommon but critical and potentially life-threatening complications of CRS, because they can be associated with severe morbidity, including visual loss. Reports from some studies indicated that the existence of an orbital complication or Pott's puffy tumour correlate with an increased risk of intracranial complications [39,40]. Orbital complications were 3.5% of total cases, with orbital cellulitis accounting for 2.1%, while orbital abscess constituted 1.4% of findings in this study. Similarly, Radovani et al. reported 19.8% of orbital complications of sinusitis, with palpebral inflammatory oedema as the most common, followed by orbital cellulitis [41]. This value was significantly higher than the finding in the index study because they used different methodology and inclusion criteria on patients who had surgical intervention and possibly complicated conditions and exclude soft tissues, and intracranial complications, while we included all CRS patients who had CT PNS and excluded those with previous surgical intervention [41]. These complications arise from the spread of infection from the sinuses to the orbital structures due to the proximity of the ethmoid sinuses to the medial orbital wall and the relatively weak barrier of the lamina papyracea, which can lead to severe consequences, including visual loss, if not promptly identified and treated.

Limitations of the study include this study were a retrospective cross-sectional one, where the association of CT L-M score to clinical features and treatment outcome was not determined and convenience sampling method was used, which is associated with low generalizability to target population because of limited resources and high out-of-pocket healthcare service payment in our

setting for CT scan which may lead to selection bias; a CT PNS was requested in some patients but it was not done because of the relatively high cost and high proportion of patients have out-of-pocket payment of healthcare services in north-eastern Nigeria; and 'Boko haram' insurgency in the region has high impact on the villages and towns which generally affect issues of accessibility and affordability of tertiary healthcare services including CT imaging; and some patients have incomplete record of clinical information, which restricted the study to correlate it with the imaging findings and these might lead selection/sampling bias. We recommend conducting multicentre study on the correlation of clinical information with imaging findings in near-future research.

CONCLUSION

The study highlighted the importance of the CT Lund-Mackay score to evaluate the severity of chronic rhinosinusitis (CRS), the prevalence and patterns of sinus involvement. In this study, the maxillary sinus was the most commonly involved, the sporadic pattern was the most inflammatory pattern among patients with CRS, and the sinonasal polyp/retention cyst was the most common complication. One-third of patients with CRS have a significant CT Lund-Mackay score in the index study.

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