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ORIGINAL RESEARCH

3D evaluation of the maxillary sinus volumes in patients with bilateral cleft lip and palate

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Abstract

One of the most common congenital anomalies of the head and neck region is a cleft lip and palate. This retrospective case-control research aimed to compare the maxillary sinus volumes in individuals with bilateral cleft lip and palate (BCLP) to a non-cleft control group. The study comprised 72 participants, including 36 patients with BCLP and 36 gender and age-matched control subjects. All topographies were obtained utilizing Cone Beam Computed Tomography (CBCT) for diagnostic purposes, and 3D Dolphin software was utilized for sinus segmentation. Volumetric measurements were taken in cubic millimeters. No significant differences were found between the sex and age distributions of both groups. Additionally, there was no statistically significant difference observed between the BCLP group and the control group on the right and left sides ($p > 0.05$). However, the mean maxillary sinus volumes of BCLP patients (8014.26 ± 2841.03 mm^3) were significantly lower than those of the healthy control group (11,085.21 ± 3146.12 mm^3) ($p < 0.05$). The findings of this study suggest that clinicians should be aware of the lower maxillary sinus volumes in BCLP patients when planning surgical interventions. The utilization of CBCT and sinus segmentation allowed for precise measurement of maxillary sinus volumes, contributing to the existing literature on anatomical variations in BCLP patients.

Keywords

Bilateral cleft lip-palate; Cone-beam computed tomography; Maxillary sinus; Volume

1. Introduction

Cleft lip and palate deformity (CLP) arises due to the incomplete fusion of the maxillary and medial nasal processes during embryonic development, particularly in the formation of the primary palate. CLP represents a significant portion of craniofacial abnormalities, accounting for approximately 15% of such deformities [1]. Individuals affected by CLP manifest unique anatomical and morphological anomalies, culminating in a spectrum of health challenges encompassing physiological, otologic, audiologic and rhinologic issues. Insights gleaned from research involving both animal models and untreated cleft patients have unveiled noteworthy retardation in the development of midfacial anatomical structures. This complex interplay of structural aberrations underscores the multifaceted nature of CLP, which extends beyond mere aesthetic concerns, encompassing a wide array of functional and physiological ramifications [2, 3]. The understanding of maxillary sinus development and aeration in individuals with CLP remains incomplete and requires further investigation.

Patients with CLP are indeed anticipated to exhibit morphological changes in the maxilla, which can lead to drainage abnormalities and an increased susceptibility to sinusitis [4, 5]. In addition to this factor, in patients with cleft lip and palate (CLP), several factors contribute to the predisposition of maxillary sinusitis, including recurrent upper respiratory infections, regurgitation of saliva and food through the cleft, velopharyngeal insufficiency, and nasal mucociliary dysfunction [4, 6]. Consequently, CLP patients often require endoscopic sinus surgery due to the frequent occurrence of sinus infections. The maxillary sinus, which represents a significant component of the midface, assumes a pivotal role as a target in endoscopic sinus surgery. Thus, the evaluation of the morphological alterations and volume of this extensively affected sinus holds considerable importance.

The maxilla is a polyhedral bone characterized by intricate anatomical features; its evaluation by conventional methods is insufficient. The majority of morphological and volumetric studies on the maxilla have relied on 2-dimensional (2D) radiographs. However, the advent of cone beam computed tomography (CBCT) has significantly improved medical imaging, especially in pediatric cases. CBCT accuracy is comparable to MSCT [7], providing a notable reduction of approximately 8 to 10 times lower than MSCT without sacrificing accuracy. Recent technological progress has shifted the paradigm of assessing maxillary sinus size and patency from theoretical cross-sectional area calculations to precise volume modeling [8]. Advanced software facilitates three-dimensional (3D) reconstructions of anatomical structures, including the maxillary sinus, providing a state-of-the-art approach to detailed anatomical analysis. CBCT's 3D modeling excels in visualizing anatomic landmarks, overcoming issues like magnification errors and image distortion frequently encountered in cephalometric imaging, making it a superior choice for anatomical assessments [9]. CBCT imaging enables a comprehensive 3D analysis of maxillary sinus aeration without the need for magnification. Moreover, research has demonstrated that CBCT images provide superior information compared to conventional imaging techniques when it comes to treatment planning for patients with CLP [10]. The utilization of three-dimensional (3D) analysis in CBCT has emerged as a prevalent method for evaluating anatomical modifications in craniofacial tissues among individuals with CLP [11–14]. This approach is particularly essential for accurately assessing the intricate anatomy of the maxilla, thereby minimizing distortions in the evaluation process. Recently, several CBCT studies employing 3D analysis have investigated the volume of the maxillary sinus (MSV) in individuals affected by cleft conditions [12, 15].

As a result of the literature review, it was determined that previous studies in patients with CLP focused on two-dimensional methods and CT; this points to a gap in the existing literature on the subject [16–18]. Additionally, the value of our study is that few studies in the literature have examined MSV in BCLP patients. This study was designed to contribute to knowledge. The purpose of this study was to examine and compare the MSV on CBCT of individuals with bilateral cleft lip and palate (BCLP) with those of well-matched healthy control subjects. Furthermore, the study sought to compare the MSV in both groups on the right and left sides and sexes.

2. Material and methods

2.1 Clinical data

To achieve a sufficient sample size, data were gathered from two different centers. CBCT scans of 36 patients with non-syndromic BCLP and 36 control patients were retrospectively selected from the archives of Necmettin Erbakan University, and Eskişehir Osmangazi University, Faculty of Dentistry, Oral and Maxillofacial Radiology Departments. CBCT images were obtained from patients who had CBCT scans performed for a variety of other dental/medical reasons, and no prospective CBCT scans were performed for the current study. The healthy control group also consisted of children who underwent CBCT scanning for various other dental/medical reasons (cyst, tumor, *etc.*, not affecting the maxillary sinuses), and no prospective CBCT scan was performed for this study.

The determination of the sample size was performed using G-Power (version 3.1.9.2; Heinrich-Heine-Universitat Dusseldorf, Dusseldorf, Germany). Each group necessitated a minimum of 34 patients, considering a bilateral Student t-test for independent samples, a significance level of 0.05, an allocation rate of 1:1, and a power of 90% to display an effect size of 0.80 for the maxillary sinus volume in a BCLP and control groups.

The images utilized in this retrospective study were from diagnostic records collected during dental procedures for both the study and the control groups. Individuals who had diseases such as Paget's disease, Wegener's granulomatosis, fibrous dysplasia, and thalassemia and who had maxillofacial trauma or surgery, retention cysts, craniofacial syndrome, mucosal thickening, previous maxillofacial neoplasia, and any type of other sinus pathology were excluded from the study. No patients were contacted for the impartiality of this study. The patient's family completed an informed permission form, allowing us to use their information for research purposes.

The current European SEDENTEX CT guidelines and the "As Low As Reasonably Achievable" principle (ALARA) were considered while taking CBCTs. Healthy control patients were matched by gender and age with the BCLP patients. CBCT was obtained with 90 kVp, 5 mA, 360° rotation and 17.5 s. Parameters in the Morita 3D Accuitomo 170 device (J Morita MFG Corp., Kyoto, Japan) and 94 kVp, 14 mA, 360° rotation, and 27 s. parameters in the Promax 3D Mid device (Planmeca, Helsinki, Finland). Sinus segmentation was applied using 3D Dolphin 11.95 Imaging software (Dolphin Imaging & Management Solutions, Patterson Technology, Chatsworth, CA, USA). Segmentation of the sinuses and mask extraction were performed manually. On the sagittal, coronal, and axial planes, the attachments between the sinuses and the nasal cavity were obliterated (Fig. 1). The MSV was calculated by the software after editing the masks. The measurements were made by the same author (A.A.), and the unit for the volumetric measurements was in mm^3 (Fig. 2).

2.2 Statistical analysis

To minimize the impact of random errors, 30 patients were randomly selected for the study, and their sinus volumes were measured by the same radiologist on two separate occasions, with a three-week interval between measurements. The dependability coefficients calculated using the Houston approach validated the reliability [19]. The reliability of the measurements was assessed by performing intraclass correlation coefficients (ICC), and a paired sample t-test was used to test the difference between both groups. The Kolmogorov-Smirnov test was used to check the normality of the data. All data for BCLP was normally distributed with homogeneous variance. Therefore, parametric tests were done for the evaluation of the volumetric data. The MSV differences on both sides of the BCLP and control patients were calculated by using a paired sample t-test. There was not any significant difference between the right and left sides. Then, we used an independent sample t-test for the evaluation of the differences in mean MSV between the control and BCLP patients. Significant p-values less than 0.05 were accepted. The statistical package for social sciences software, 21.0 (SPSS for Windows; SPSS Inc., Chicago, IL, USA), was used for the statistical analysis.

3. Results

This study evaluated 72 patients, including 36 (19 females, 17 males) with and 36 (18 females, 18 males) without CLP. The BCLP and control patients had a mean age of 9.23 ± 2.37 years,

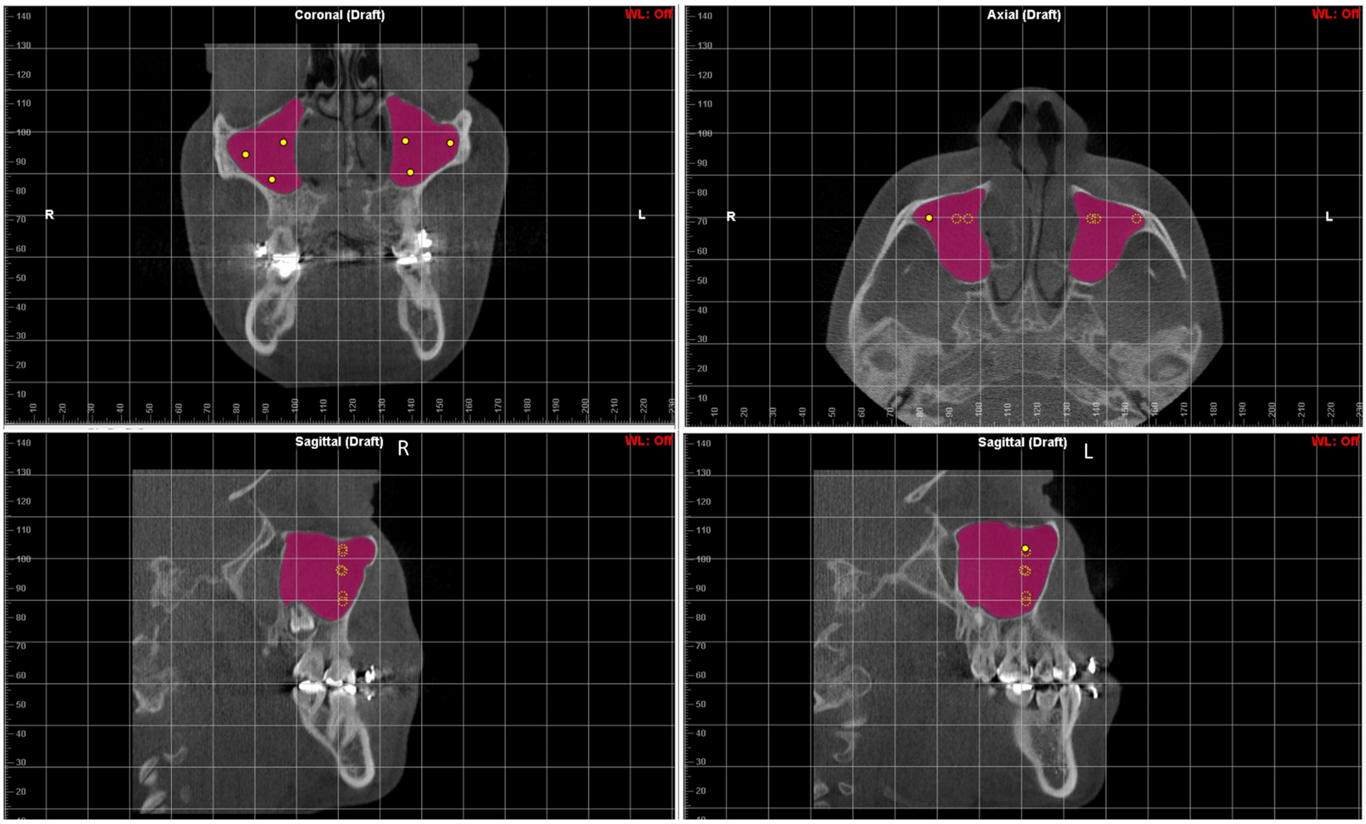

FIGURE 1. Coronal, axial and sagittal MSV segmentation. Analysis of the maxillary sinus on 3D Dolphin 11.95 Imaging software (Dolphin Imaging & Management Solutions, Patterson Technology, Chatsworth, CA, USA). Selection of the region of interest on 3 space (coronal, sagittal, axial) reference planes and then, the initiation seeds were applied to the inner part of the maxillary sinus.

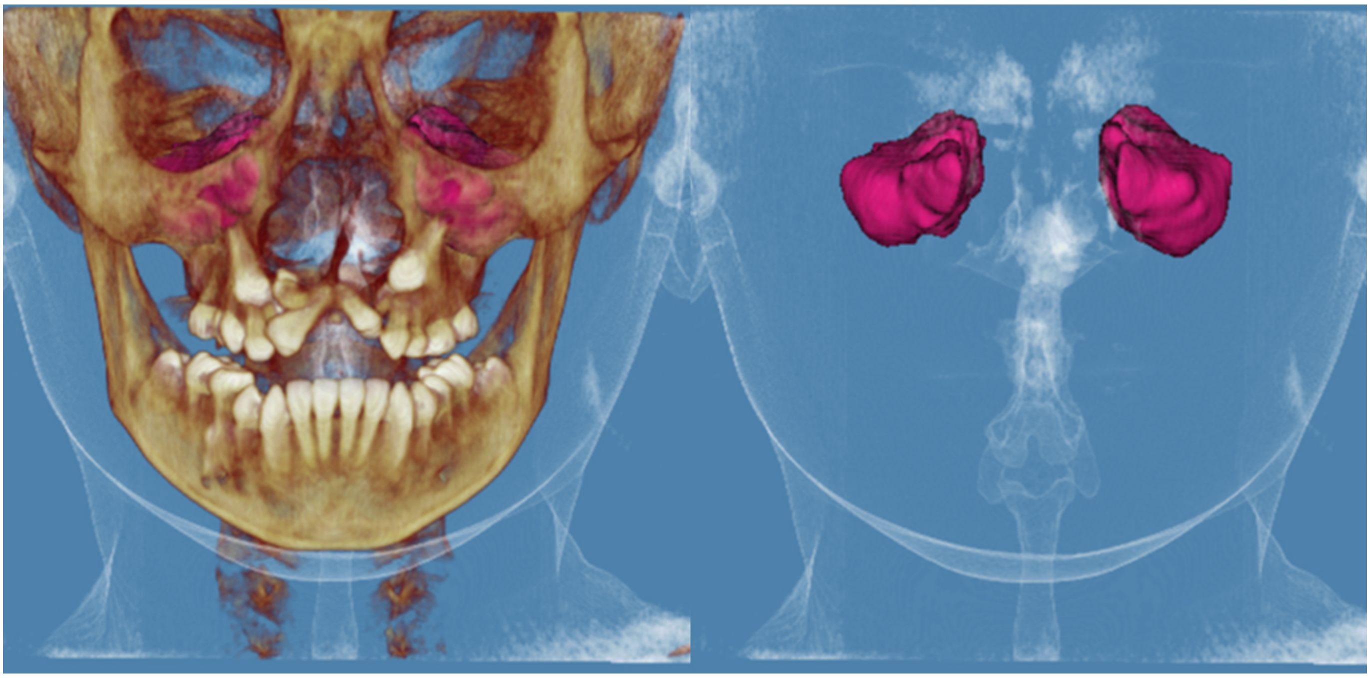

FIGURE 2. 3D reconstruction of the bilateral cleft lip and palate patient and maxillary sinus volume demonstration. The process involves generating a 3D image by assembling adapted slices, which are subsequently used by the software to calculate the volume of both the right and left maxillary sinuses in cubic millimeters (mm^3). This results in a detailed 3D anatomical model for analysis.

ranging from 7–16, and 9.25 ± 2.49 years, ranging from 7–16, respectively (Table 1). As a result, a total of 144 sinuses were evaluated. The ICC values (0.991) confirmed the reliability of the measurements ($p > 0.05$). Descriptive statistics and comparisons between the two side sinuses of the control and BCLP patients are shown in Table 2.

The first statistical analysis was performed to compare the volumes of the sinuses between the sides. No significant differences ($p > 0.05$) were found between the sex and age distributions of both groups. For this, a paired sample *t*-test was used, and there was no significant difference ($p > 0.05$) between the volume of the maxillary sinuses on the right and left sides for both the control group and the BCLP patients (Table 2).

In terms of intergroup comparison, we observed that the mean maxillary sinus volume of the control group (11,085.21 ± 3146.12 mm^3) was significantly larger than the mean maxillary sinus volume of BCLP patients (8014.26 ± 2841.03 mm^3), with a *p*-value less than 0.05 (Table 3).

4. Discussion

In this retrospective case-control study, the maxillary sinus volumes (MSV) of 36 non-syndromic individuals with bilateral cleft lip and palate (BCLP) were evaluated using cone-beam computed tomography (CBCT). A comparative analysis was conducted, employing a control group of 36 age- and gender-matched non-cleft individuals. Cases involving incomplete clefts and unilateral cleft lip and palate (UCLP) were excluded. Volumetric measurements revealed a statistically significant reduction in MSV among BCLP patients compared to the non-cleft control group ($p < 0.05$). However, no significant differences were observed between the right and left sides of the maxillary sinuses in BCLP individuals ($p > 0.05$).

Patients with cleft lip and palate (CLP) commonly experience a range of rhinologic complications, with nasal airway obstruction being particularly prevalent. This obstruction is typically attributed to factors such as septal deviation, turbinate hypertrophy, external nasal deformities and rhinosinusitis [20]. In addition to the dentofacial anomalies associated with CLP, nasal obstruction can also contribute to morphological changes in the maxillary complex. CLP patients exhibit a higher susceptibility to maxillary sinusitis compared to individuals

TABLE 1. Chronological ages of the groups.

	Age (yr)					
	BCLP			Control group		
	n	Mean	Std. D.	n	Mean	Std. D.
Female	19	9.31	2.59	18	9.45	2.85
Male	17	9.14	2.05	18	9.05	2.31
Total	36	9.23	2.37	36	9.25	2.49

Std. D.: Standard deviation; BCLP: bilateral cleft lip and palate.

TABLE 2. Gender differences in MSV in the BLCP, and Control Group in the right-left sides.

	BCLP Maxillary Sinus Volumes (mm^3)							
	Right			*p* value	Left			*p* value
	n	Mean	Std. D.		n	Mean	Std. D.	
Female	19	7612.23	2589.43		19	7779.12	2541.27	
Male	17	8662.38	3327.16	0.553	17	8078.25	3097.45	0.582
Total	36	8108.14	3012.52		36	7920.38	2776.14	
	Control Group Maxillary Sinus Volumes (mm^3)							
Female	18	12,124.53	2987.13		18	11,024.62	2896.42	
Male	18	10,245.25	2725.26	0.137	18	10,946.44	2728.86	0.496
Total	36	11,184.89	2968.16		36	10,985.53	2877.36	

BCLP: bilateral cleft lip and palate.

TABLE 3. MSV comparison between the BLCP and control group and between the right and left sides.

	Right			*p* value	Left			*p* value	Total			*p* value
	n	Mean	Std. D.		n	Mean	Std. D.		n	Mean	Std. D.	
BLCP	36	8108.14	3012.52	*0.001	36	7920.38	2776.14	*0.001	72	8014.26	2841.03	*0.001
Control	36	11,184.89	3127.16		36	10,785.53	3277.36		72	10,985.21	3146.12	

*Independent T-test. BCLP: bilateral cleft lip and palate; *: $p < 0.05$.*

without CLP [21]. While several factors influence the development of this infection, the precise etiopathogenesis remains incompletely understood in the context of CLP patients. Numerous factors can contribute to the occurrence of maxillary sinusitis in individuals with cleft; however, the underlying causes have yet to be fully elucidated [21].

The measurement of sinus growth and aeration level is important in understanding rhinosinusitis in individuals with CLP [22]. The increased frequency of sinusitis in this patient population has been related to decreased maxillary size as well as ostium malposition and constriction [21, 23]. Recent studies have focused on investigating paranasal sinuses in CLP patients, yet certain investigations examining maxillary sinus volume (MSV) failed to reveal significant differences between CLP patients and the control group [2, 5]. On the other hand, specific specialists who conducted assessments of the maxillary complex discovered differences in both dimensions and symmetry between individuals with CLP and their healthy counterparts [16, 23]. For instance, Agarwal *et al.* [16] utilized computed tomography (CT) and reported reduced maxillary length, height, depth and volume on the cleft side compared to the non-cleft side [21]. These findings were attributed to skeletal hypoplasia associated with the presence of the cleft. However, most of these studies utilized conventional radiography or CT with predominantly 2-dimensional (2D) assessments.

CBCT is a valuable and appropriate imaging modality for investigating the detailed and accurate anatomical information of the maxilla and midfacial structures in patients with CLP [10–14, 23]. It has been demonstrated that CBCT enables a comprehensive evaluation of the anatomical features in CLP patients, offering a three-dimensional (3D) view of the structures of interest in all planes [10, 23]. The advantages of CBCT over other imaging techniques include its capability to provide precise and detailed images while minimizing radiation exposure, thus making it a preferred imaging modality for assessing individuals with CLP [23, 24]. Cone-beam computed tomography (CBCT) imaging features offer valuable insights into the manifestation of maxillary sinusitis. The high-resolution imaging facilitates the identification of specific sinusitis-associated characteristics. Noteworthy findings on CBCT imaging in cases of maxillary sinusitis encompass mucosal thickening, the presence of fluid and air-fluid levels, sinus cavity opacification, and variations in sinus wall integrity. These distinctive features play a pivotal role in the precise diagnosis and evaluation of the extent and severity of maxillary sinusitis. The three-dimensional visualization afforded by CBCT is instrumental for clinicians in scrutinizing spatial relationships and comprehending anatomical alterations linked to sinusitis [25, 26].

In this study, CBCT was utilized, and the obtained ICC values for all the variables exceeded 0.991, indicating the high reliability of the data.

Several studies have investigated the MSV in individuals with CLP utilizing 3D reconstruction techniques [2, 12, 15, 16]. However, the findings of these studies have yielded inconsistent results. For instance, Rong *et al.* [27] employed 3D evaluation of CT to examine the MSV in cleft patients and healthy controls, and their investigation revealed no significant alterations in volume. Similarly, Hikosaka *et al.* [2] conducted a study utilizing 3D reconstruction of CT to assess the MSV in 109 patients with cleft alveolus, comparing it to that of 50 control patients. Their findings indicated no statistically significant differences in MSV between individuals with cleft alveolus and non-cleft individuals.

Contrary to studies reporting no significant differences in MSV between cleft and non-cleft individuals, there exists evidence that contradicts this notion. Barbosa *et al.* [15] recently conducted a study aimed at comparing the MSV among three groups: 30 patients with UCLP, 15 patients with BCLP, and 15 control patients. The investigation utilized three-dimensional (3D) reconstructions derived from CBCT [15]. The findings of the study demonstrated that both UCLP and BCLP patients exhibited a lower MSV compared to the control group. However, no statistically significant difference was observed in MSV between the BCLP and UCLP patient subgroups.

Another study utilizing 3D reconstruction of CBCT assessed the MSV in patients with UCLP compared to healthy controls. The findings indicated a statistically significant decrease in MSV among UCLP patients. Notably, within the UCLP patient group, there were no significant differences in volumes between the non-cleft and cleft sides [12]. These findings align with previous studies conducted by Erdur *et al.* [12] and Barbosa *et al.* [15], which also reported no significant differences between the cleft side and non-cleft side in UCLP patients. However, Hikosaka *et al.* [2] observed that the volume of the non-cleft side was greater than that of the cleft side in UCLP patients. Similarly, the present study's results demonstrated statistically significant differences in MSV between patients with BCLP and non-cleft controls. The mean MSV of non-cleft individuals was significantly higher than that of BCLP patients ($p < 0.05$), as revealed through intergroup comparisons.

Numerous studies have investigated the bilateral comparison of MSV in healthy individuals, revealing consistent results indicating no significant differences between the right and left sides [28]. However, discrepancies arise when examining cleft patients. Hikosaka *et al.* [2] observed that the right sinuses of cleft patients exhibited larger volumes compared to the left sinuses. In contrast, studies conducted by Erdur *et al.* [12] and Barbosa *et al.* [15] reported no significant differences between the right and left sides of MSV in cleft patients. In the present study, no statistically significant difference in MSV was found between the right and left sides in patients with BCLP and the control group.

The pathogenesis of sinusitis in patients with CLP remains elusive, and multiple theories have been proposed to elucidate its underlying causes. The etiology of this condition is considered multifactorial and complex, with various factors potentially contributing to its development [21, 29]. Furthermore, it is well established that individuals with chronic sinusitis often exhibit smaller MSV [30]. However, despite numerous studies investigating the paranasal sinuses of CLP patients, the precise mechanism by which sinusitis develops in this population remains uncertain. It is plausible that the reduced MSV observed in CLP patients may be attributed to previous episodes of chronic sinusitis [21, 30]. Nevertheless, understanding this aspect could prove beneficial for surgeons performing future endoscopic sinus surgeries on CLP patients, as it may aid in the prevention of orbital damage by ensuring appropriate precautions are taken.

Darsey *et al.* [31] used CBCT imaging to examine the effect of the Hyrax expansion device on MSV and nasal cavity volume. Their findings revealed no statistically significant alteration in MSV; however, a significant increase in nasal cavity volume was observed following expansion. In a similar vein, Pangrazio *et al.* [32] used CBCT images to examine the effects of two different expansion appliances (bonded and banded) on maxillary sinus and nasal cavity volume. Their findings revealed an increase in both nasal cavity and maxillary sinus volume after wearing either device, with no statistically significant differences between the two types of appliances. Furthermore, Erdur *et al.* [33] used CBCT images to assess the effects of symmetrical and asymmetrical rapid maxillary expansion (RME) appliances on MSV and pharyngeal airway volume. The authors concluded that both appliance types led to an augmentation in both MSV and pharyngeal airway volume. These collective findings suggest that expansion appliances contribute to an increase in maxillary sinus volume. It is noteworthy that the maxillary sinus appears to adapt and remodel itself to accommodate the transversal bone alterations induced by orthodontic treatments, a factor that is needed by clinicians when considering orthodontic interventions for individuals with CLP.

Repair of cleft alveolar bone is done using alveolar bone grafting (ABG). The ABG application was first reported by Von Eiselberg in 1901. Von Eiselberg used a pedicled osteocutaneous flap to reconstruct the palatal cleft [34, 35]. The first successful bone graft application to the alveolar defect was performed by Drachter in 1914 [36]. Drachter used tibial bone tissue, including the periosteum. Alveolar bone grafting is applied in primary ABG (the first two years following birth), early ABG (between the ages of 4–7), ABG in the mixed dentition (between 7–12), and late ABG (after the completion of the permanent dentition). It is recommended that the ideal age is before the canine teeth erupt (between the ages of 8–11) and using an autogenous bone graft [36]. It should be taken into consideration that bone graft application may cause the maxillary sinus and therefore its volume to change by changing the stress distribution.

In the study conducted by Demirtaş *et al.* [37], encompassing a cohort of 44 individuals diagnosed with UCLP and an equivalent number of healthy controls, statistically significant distinctions were observed between the patient and control groups concerning MSV. Moreover, the MSV was found to be lower in the patient group presenting with UCLP. In the study by Yılmaz *et al.* [38], which assessed MSV in 30 UCLP patients and 30 healthy counterparts, the right MSV was reported as 14,393.5655 ± 3698.6789 and 12,564.464 ± 4673.2152 for the control and patient groups, respectively. Conversely, the left MSV was measured at 11,240.3975 ± 4647.1791 and 15,001.718 ± 4123.3595, respectively. Although no statistically significant differences were discerned in right-sided volume measurements, UCLP patients exhibited statistically significant reductions in MSV on the left side, compared to their healthy counterparts. Notably, the volumetric values obtained in Yılmaz *et al.*'s [38] study exceeded those observed in the current investigation. This discrepancy may potentially be attributed to the disparity in age demographics, as the older age group in their study could have influenced the volumetric measurements. However, it is worth emphasizing that volumetric comparisons between UCLP patients and control groups are consistent with the results from the current study.

Rodrigues *et al.* [39] conducted a comprehensive investigation and determined that there was no statistically significant difference in MSV among individuals with UCLP ($p = 0.677$). However, within the cleft group, the affected side exhibited a significantly lower volume compared to the contralateral side ($p < 0.001$). Additionally, notable variations in MSV were observed between patients with and without clefts, with gender showing statistical significance ($p = 0.001$) and age exhibiting a highly significant difference ($p < 0.001$). Contrary to this study, the present study revealed a significant difference in MSVs between the control group and individuals with BCLP; however, no gender-related differences were detected. These inconsistencies across studies may be attributed to variations in age groups, demographic factors, and different subgroups of cleft lip and palate patients.

Paknahad *et al.* [5] investigated nasal septum deviation, mucosal thickness, and maxillary sinus height and depth in both UCLP and BCLP patients. Their findings demonstrated that the cleft lip and palate groups had significantly lower maxillary sinus depth and height compared to non-cleft individuals. Unlike the current study, Paknahad *et al.* [5] employed three-dimensional assessments and calculated the sinus volume, which aligns with their two-dimensional findings.

Yassei *et al.* [40] examined 27 patients with UCLP using CBCT. The findings revealed no significant mean volume and height differences between the cleft and non-cleft sides. However, the base area of the sinus on the cleft side was significantly larger, indicating potential differences in the sinus's shape. The age-based analysis unveiled intriguing trends. Among patients under 20 years old, the volume of the upper sinus on the cleft side was slightly smaller. In contrast, for those older than 20 years, the upper sinus on the cleft side was notably larger. Additionally, the volume of the lower sinus on the cleft side was significantly smaller than on the non-cleft side. These results underscore the intricate variations in maxillary sinus morphology in patients with UCLP.

Tunç and Unsal [41] utilized CBCT to investigate sinus volumes in 80 patients with UCLP and 80 healthy individuals. In the UCLP group, ethmoid and sphenoid sinus volumes did not significantly differ between the cleft and non-cleft sides ($p > 0.05$), whereas the maxillary sinus on the cleft side was notably smaller than the non-cleft side ($p < 0.05$), indicating a mean volume of 11,825.23 ± 509.95 mm^3 on the cleft side and 13,497.85 ± 358.07 mm^3 on the non-cleft side. Furthermore, in comparison to healthy individuals, UCLP patients exhibited significantly lower mean volumes for both maxillary and frontal sinuses ($p < 0.05$), with mean MSVs of 25,323 ± 597.8 mm^3 in UCLP patients and 26,666 ± 874.3 mm^3 in the control group, as well as mean frontal sinus volumes of 5633 ± 323.1 mm^3 in UCLP patients and 5735 ± 315.2 mm^3 in healthy individuals. These findings highlight significant variations in sinus volumes in UCLP patients, with potential implications for clinical management.

This study is subject to several limitations. It is retrospective, and due to its radiological focus, clinical symptoms associated with these pathologies could not be assessed. Furthermore, the sample size of our study was constrained, primarily due to the exclusion criteria applied in participant selection and the specific age range considered.

It should be noted that this study exclusively assessed the pre-treatment sinus volumes of BCLP patients. Future research endeavors may consider the evaluation of maxillary sinus volumes in BCLP patients both before and after orthodontic interventions.

It is worth noting that the existing literature predominantly features studies conducted on UCLP patients. Despite these inherent limitations, our study contributes as one of the few investigations evaluating MSVs in children with BCLP as well as in non-cleft individuals.

5. Conclusions

This study conducted an in-depth analysis of maxillary sinus volume (MSV), unveiling a noteworthy reduction in MSV among individuals with bilateral cleft lip and palate (BCLP) compared to their non-cleft counterparts. Furthermore, no statistically significant disparities in MSV were detected between the right and left sides in BCLP patients. It is recommended that future studies include larger sample sizes to comprehensively understand the consequences of reduced maxillary sinus volume and its potential association with conditions such as rhinosinusitis. Such endeavors would provide a more comprehensive understanding of the complex interplay between maxillary sinus volume and associated pathologies.

AVAILABILITY OF DATA AND MATERIALS

Most of the relevant data are available in the main text; further data are available from the corresponding author upon reasonable request.

AUTHOR CONTRIBUTIONS

AA, EAE and ÖE—designed the study. AA, EAE and İŞB—collected the data. AA and EAE—performed the research. AA, EAE, ÖE and İŞB—analyzed the data. All authors wrote the manuscript. All authors contributed to editorial changes in the manuscript. All authors have read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study conforms to the Helsinki Declaration and was confirmed by the Ethics Committee of Necmettin Erbakan University Faculty of Dentistry (date 23 February 2023, decision number: 2023/258). Informed consent was obtained from all subjects involved in the study (informed consent was obtained from the parent or legal guardian of patients under 16).

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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