A Comparison of Inferior Turbinate Hypertrophy in Pediatric Patients with Cleft Lip and Palate

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Background: Nasal septum deviation can cause compensatory inferior turbinate hypertrophy (ITH) on the unobstructed side. Patients with unilateral cleft lip and palate (UCLP) are prone to develop compensatory ITH on the non-cleft side due to nasal septum deviation. However, the prevalence of ITH in patients with bilateral complete cleft lip and palate (BCLP) and SMCP is still unclear. Patients with cleft lip and palate have been found to have more severe nasal septum deviation than patients without.

Objective: The primary aim of this study was to compare the prevalence of ITH in patients with BCLP, UCLP and submucous cleft palate (SMCP) using lateral cephalometric radiographs. The secondary aim was to compare the prevalence of ITH in patients with complete cleft, i.e. BCLP and UCLP, and in healthy controls.

Methods: Lateral cephalometric radiographs of pediatric patients with BCLP, UCLP, and SMCP treated at UPMC Children's Hospital of Pittsburgh Orthodontics Department were examined to determine the prevalence of ITH in each group. Lateral cephalometric radiographs from the Bolton Brush Growth study (AAOF) were examined to determine the prevalence of ITH in healthy population. Ten percent of the radiographs were reexamined 1 month after the initial examination to determine intra-rater reliability. Chi square test was used to determine if there was a significant difference in the prevalence of ITH among the groups with cleft, and between patients with complete cleft and the AAOF. Regression analysis was performed to determine the odds ratio

of ITH among the cleft groups, and the odds ratio of ITH in patients with complete cleft compared to the AAOF group. Kappa test was used to calculate the intra-rater reliability.

Results: No statistically significant difference was found in the prevalence of ITH among the cleft groups before and after adjusting for confounders. The prevalence of ITH was significantly higher in patients with complete cleft than the AAOF subjects.

Conclusions: Patients with BCLP, UCLP or SMCP have the same risk of developing ITH. Patients with complete cleft are more likely to develop ITH than healthy subjects.

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1.0 Background

1.1 Nasal Septum Deviation and Inferior Turbinate Hypertrophy

Nasal septum deviation and inferior turbinate hypertrophy (ITH) are both common causes of nasal airway obstruction in pediatric and adult patients(Clark et al. 2018; Smith and Ishman 2018; Macari and Haddad 2016). Nasal septum deviation can be a result of aberrant septal growth or previous trauma. In patients without an explicit history of nasal injury, birth trauma and microfracture have been suggested to be the causes of abnormal septal growth and deviation (Holt 1999; Harugop et al. 2012). Although not all the anatomic asymmetry will lead to clinical symptoms, significant nasal septum deviation has been found to disrupt nasal airflow and result in nasal airway obstruction (Liu et al. 2012). Depending on the location of the deviation, the prevalence of septal deviation in school-age children range between 0.7% to 28.7% (Haapaniemi et al. 1995).

Inferior turbinate contains a rich vascular supply and serves the function of warming and humidifying the inspired air by maximizing the intra-nasal surface area (Hsu and Suh 2018). Meanwhile, inferior turbinate is the posterior boundary of internal nasal valve on each side of the nose (Wright, Grunzweig, and Totonchi 2020). Since internal nasal valve is the narrowest portion of the nasal airway and has the greatest resistance to airflow, any increase in the dimensions of inferior turbinate can lead to increased airway resistance (Hsu and Suh 2018). Indeed, ITH has been found to contribute to up to two-thirds of increased nasal airway resistance (Wright, Grunzweig, and Totonchi 2020).

In patients with nasal septal deviation, inferior turbinate on the unobstructed side has been found to undergo compensatory hypertrophy as the result of increased airflow (Farmer and Eccles 2006; Sharhan et al. 2018; Aslan et al. 2013). Some studies have shown that compensatory ITH due to septal deviation is bony enlargement whereas ITH caused by infections and inflammations is mucosal thickening(Berger et al. 2000; Berger, Gass, and Ophir 2006). However, found that ITH in septal deviation is both bony and mucosal. After comparing ITH in traumatic septal deviation and non-traumatic septal deviation, (Korkut et al. 2012) suggested that in traumatic septal deviation cases, compensatory ITH is mucosal only, and that in non-traumatic septal deviation cases, the compensatory ITH is mostly skeletal.

In nasal airway obstruction caused by septal deviation, septoplasty is routinely performed to reposition the septum to the midline and reduce the airway resistance (Fettman, Sanford, and Sindwani 2009). However, although the patency of the previously obstructed side is re-established, the volume of the contralateral side may be reduced due to persistent ITH, causing increased airway resistance of the previously patent side (Jun et al. 2009). Current studies suggest that compared to septoplasty only, turbinectomy or lateralization of the inferior turbinate at the same time as the septoplasty may be more effective in improving overall airway patency and may decrease the future need of revision surgery (Akoğlu et al. 2007; Egeli et al. 2004; Jun et al. 2009; Karlsson et al. 2015; Korkut et al. 2012).

1.2 Cleft of the Lip and/or Palate

Clefts of the lip and/or palate (CL/P) are common congenital disorders with many variations in the degree and location of the cleft (Mai et al. 2019). The clefts can be unilateral or

bilateral. Based on the location, these orofacial cleft can be categorized as isolated cleft lip with or without maxillary alveolus, isolated cleft in the secondary palate only, and cleft lip and palate (Shprintzen 2002). Each category can be further divided into complete and incomplete cleft based on the degree of the cleft (Shprintzen 2002). Submucous cleft palate is a type of isolated incomplete cleft palate (Shprintzen 2002).

CL/P is the result of disrupted normal prenatal craniofacial development. Human facial development begins at fourth week after fertilization, during which the neural crest cells migrate away from the neural tube to form the five facial prominences (Jiang, Bush, and Lidral 2006). Between sixth and eighth week of gestation, the upper lip and primary palate are formed through the fusion of lateral nasal process, maxillary process and mandibular process (Jiang, Bush, and Lidral 2006). During the same period of time, the initially vertical palatal shelves elevate above the tongue to grow horizontally and fuse to form the secondary palate (Gritli-Linde 2007). Disruption of these processes will result in cleft in the lip and palate.

CL/P can occur in isolation or in association with other syndromes. Some syndromes commonly associated with CL/P include van der Woude syndrome, Treacher Collins syndrome, Pierre Robin sequence, velocardiofacial syndrome, and median facial dysplasia (Leslie and Marazita 2013; Venkatesh 2009). Although many syndromes have been found to be associated with CL/P, syndromic CL/P only make up a small percentage of CL/P patients (Leslie and Marazita 2013). For example, Van der Woude syndrome, the most common clefting syndrome, only accounts for 2% of total CL/P cases (Burdick 1986). For this reason, this present study will focus on patients with non-syndromic CL/P.

Nonsyndromic CL/P account for 70% of total CL/P (Stanier and Moore 2004). Incidence of nonsyndromic CL/P varies among different ethnicity origins. Asian and American Indians have

been found to have the highest birth prevalence rates, whereas African descendants have the lowest birth prevalence (Dixon et al. 2011). Incidence in European-derived populations is intermediate (Dixon et al. 2011). Since the structural abnormalities in patients with CL/P can lead to various clinical complications, management of patients with CL/P requires long-term multidisciplinary care that involves orthodontics, oral and maxillofacial surgery, otolaryngologist, plastic surgery, speech-language pathology, pediatrics, pediatric dentistry and audiology (Shaye, Liu, and Tollefson 2015). Early surgical repair of the cleft lip and palate to separate the nasal and oral cavities at the age of five to six months is necessary to improve feeding and facilitate speech development later on (Shaye, Liu, and Tollefson 2015). Alveolar bone grafting during mixed dentition before canine eruption may be needed to provide additional support to the maxillary arch and dentition, and improve the masticatory function (Weissler et al. 2016). Although its incidence is highly variable, oronasal fistula is one of the most common complications of primary surgical repair of cleft palate and is commonly treated with bone grafting to eliminate the communication between the nasal and oral cavity (Bykowski et al. 2015; Miranda et al. 2020; Yi, Kang, and Oh 2020).

1.3 Nasal Septum Deviation and Inferior Turbinate Hypertrophy in Patients with CL/P

1.3.1 Septum Deviation

Compared to healthy controls, septum deviation is more prevalent and severe in patients with CL/P (Jiang et al. 2014; Kyrkanides, Bellohusen, and Subtelny 1995; Massie et al. 2016; Sandham and Murray 1993). After comparing patients with UCLP and BCLP to age-matched

control subjects, Massie et al. (2016) found that the magnitude of nasal septum deviation in patients with CL/P is significantly greater at all levels from the anterior nasal spine to the posterior nasal spine. A study by Jiang et al. (2014) also showed that both patients with complete and incomplete CP have more severe nasal septal deviation compared to healthy controls.

Nasal septum deviation in CL/P may be the result of cleft formation. The nasal septum attaches to the premaxilla and the maxilla via the septo-premaxillary ligament (Latham 1970). Due to the cleft in the premaxilla and maxilla, the nasal septum is tethered asymmetrically during its growth and development (Latham 1970). Consequently, the nasal septum becomes deviated towards one side of the nose (Latham 1970; Moore et al. 2005).

The pattern and severity of septal deviation in patients with CL/P may vary based on the type and degree of the cleft. A study by Starbuck et al. (2014) indicated that the nasal septum tends to deviate towards the cleft side in UCLP, and may deviate towards either side in BCLP. Septal deviation in patients with complete palatal cleft has been found to be more severe than in patients with incomplete cleft palate and patients with cleft alveolus only (Jiang et al. 2014).

1.3.2 Inferior Turbinate Hypertrophy

ITH in UCLP has been observed and well-described by many studies (Dentino, Sierra-Vasquez, and Padwa 2016; Ridgway et al. 2011; Wei et al. 2020). Using computed tomography (CT), Dentino, Sierra-Vasquez, and Padwa (2016) compared the inferior turbinate size on the cleft side and non-cleft side in UCLP patients that had not been through rhinoplasty, septoplasty, turbinectomy or LeFort I osteotomy. They found that both the bony and mucosal dimensions of the inferior turbinate on the non-cleft side were significantly larger than on the cleft side along the entire anteroposterior length of the inferior turbinate (Dentino, Sierra-Vasquez, and Padwa 2016).

1.3.3 Management of Nasal Septum Deviation and ITH in patients with CL/P

Rhinoplasty and septoplasty are performed on patients with CL/P to correct nasal deformities, improve nasal symmetry, and reduce nasal airway obstructions. In the past, in order to avoid growth-incurred changes and the need for revision surgery, definitive rhinoplasty was usually deferred until the patient had completed growth. However, delaying rhinoplasty may worsen the nasal deformity and result in increased need for revision of the reconstruction (Pinto et al. 2018). Early septoplasty at the time of primary lip repair has been shown to produce stable improvement in nasal esthetics and function in patients with UCLP (Pinto et al. 2018; Gosla-Reddy et al. 2011).

Correction in septal deviation has been found to be associated with reduction in the size of ITH. A study by Pinto et al. (2018) showed that septoplasty along with rhinoplasty in children with UCLP significantly reduced the size of inferior turbinate post-operatively. Ridgway et al. (2011) also demonstrated that inferior turbinate width of patients received septum correction at the time of primary nasolabial repair was significantly narrower than the inferior turbinate width of patients without septum correction.

1.4 Lateral Cephalogram and Its Application in Relevant Clinical Research

Since its first development in the 20th century, lateral cephalometric radiograph has been applied in a wide variety of craniofacial clinical studies (Hans, Palomo, and Valiathan 2015). Nowadays, it is commonly used to characterize craniofacial morphology and to facilitate orthodontic diagnosis and treatment plan (Hans, Palomo, and Valiathan 2015). Although

historically lateral cephalometric radiograph was mainly used to describe skeletal characteristics and growth, recent studies have also utilized lateral cephalometric radiograph to measure soft tissue dimensions (Hersberger-Zurfluh et al. 2018; Kaur Domir et al. 2019).

Lateral cephalometric radiograph is produced by aligning the sagittal plane of the patient's head parallel to the image receptor and perpendicular to the X-ray beam using a cephalostat (Rozylo-Kalinowska 2020). The cephalostat allows the lateral ceph images to be standardized and repeatable (Rozylo-Kalinowska 2020). The cephalostat contains an ear rod and a nasal support with an embedded radiopaque scale. The ear rod is inserted into the external auditory meatus to stabilize the patient head position. The embedded radiopaque scale allows for the calculation of magnification and establish accurate linear measurements on the image (Rozylo-Kalinowska 2020).

Due to the divergent nature of the X-ray beam, radiographs tend to have various amount of magnification of the object, which is affected by the distance between the object and the X-ray source, and the distance between the object and the receptor film (Rino Neto et al. 2013). It is recommended to place the patient at least 150 centimeters away from the X-ray source to take advantage of the flat central beam to limit magnification, but no more than 400 centimeters away from the radiation source to avoid reducing the X-ray penetration (Rino Neto et al. 2013; Rozylo-Kalinowska 2020). Meanwhile, since the amount of magnification increases with greater distance between the object and the receptor film, the object should be kept as close to the receptor as possible (Rino Neto et al. 2013). By keeping the object-radiation source distance and the object-receptor film distance constant, a standardized magnification factor can be calculated (Rino Neto et al. 2013).

A previous study by Wyche, Wilmot, and Brooks (1995) utilized the lateral cephalogram to identify the frequency of radiopaque inferior turbinate among orthodontic patients treated at University of Michigan School of Dentistry, Department of Orthodontics (Wyche, Wilmot, and Brooks 1995). The radiopaque inferior turbinate was defined as the well-defined round radiopacity in the region of the posterior wall of the maxillary sinus, which appears to be superimposed on the coronoid process. This study showed that radiopaque inferior turbinate was visible on 76.8% of the 479 lateral cephalograms examined, and was not affected by age or gender.

2.0 Purpose of the Present Study

Although current evidence shows that performing early septoplasty and possibly turbinate surgery at the same time as primary lip repair in UCLP can improve nasal airway patency by reducing the size of inferior turbinate, it is still unclear whether early septoplasty and turbinate surgery is necessary for children with other types of clefts (Pinto et al. 2018). Investigation of the prevalence of ITH in other types of clefts may help to clarify the necessity of early septoplasty and possible turbinectomy for patients with non-UCLP clefts.

The primary goal of the present study is to investigate the prevalence of ITH in non-syndromic UCLP, BCLP, and SMCP patients and determine if the prevalence of ITH varies based on the type of cleft. The secondary goal is to determine if having complete cleft (i.e. BCLP and UCLP) is associated with increased ITH compared to healthy controls.

The primary goal of the present study is to investigate the prevalence of ITH in non-syndromic UCLP, BCLP, and SMCP patients and determine if the prevalence of ITH varies based on the type of cleft. The secondary goal is to determine if having complete cleft (i.e. BCLP and UCLP) is associated with increased ITH compared to healthy controls.

3.0 Methods

The study was approved by the Institutional Review Board at the University of Pittsburgh Medical Center (UPMC). Since patients with persistent oronasal fistula tend to experience more nasal irritation due to the communication between the oral cavity and nasal cavity, presence of oronasal fistula after primary cleft repair is a potential confounder. The samples included will be subjects that have completed the primary cleft repair and bone graft for oronasal fistula.

3.1 Sample Description

Lateral cephalometric radiographs of patients with cleft lip and palate treated at UPMC Children's Hospital of Pittsburgh (CHP) Orthodontics Department were collected. Radiographs of the patients that met the following criteria were included: (1) clinical diagnosis of non-syndromic BCLP, UCLP or SMCP; (2) lateral cephalometric radiograph taken at CHP between 2013 and 2022; (3) equal or younger than 18 years of age at the time of radiograph acquisition; (4) completed primary cleft repair and bone graft if oronasal fistula developed after the primary cleft repair. Exclusion criteria of the present study included: (1) presence of non-cleft-related craniofacial comorbidity that also affect the nasopharyngeal area; (2) history of facial trauma, nasal fracture and/or skull fracture; (3) syndromic CL/P; (4) Veau type I and II cleft (incomplete cleft); (5) history of definitive rhinoplasty, septoplasty and/or turbinate reduction surgery.

The presence of oronasal fistula could cause increased irritation of nasal cavity (Sadhu, 2009) and may complicate the identification of ITH on the radiograph. In order to minimize the effect that oronasal fistula might have on ITH, if multiple lateral cephalometric radiographs before age 18 were available for a subject, the radiograph taken at the oldest age was used.

Lateral cephalometric radiographs from the Bolton-Brush growth study (AAOF) in the "Condensed Legacy Collection Inventory" that are available on the American Association of Orthodontists Foundation Craniofacial Growth Legacy Collections website were used as the healthy control. Since each subject had multiple lateral cephalometric radiographs taken at different ages, the lateral ceph taken at the oldest age before 18 years was used for each patient.

3.2 Data Acquisition

The samples were divided into four categories: unilateral complete cleft lip and palate (UCLP), bilateral complete cleft lip and palate (BCLP), submucous cleft palate (SMCP), and healthy control (AAOF). For each category, the presence or absence of radiopaque inferior turbinate was determined by visual examination of the lateral cephalometric radiographs. The lateral cephalometric radiographs of the patients with clefts were all obtained using the same machine (Planmeca Promax Dimax 3, Henry Schein Equipment & Technology). For patients that weighed over 120 lbs, the setting of 70 mV and 5 mA was used. The setting of 68 mV and 5 mA was used on all the other patients.

The primary outcome was the prevalence of ITH in each of the four categories (BCLP, UCLP, SMCP and AAOF). ITH in patients with non-traumatic septal deviation usually involves

skeletal enlargement, which can be visualized on radiographic images. The definition of radiopaque inferior turbinate by Wyche et al (1995) was used for the current study. The included radiographs were examined to determine the presence or absence of ITH. Examples of subjects with and without ITH were shown in Figure 1 and Figure 2 respectively. When there appeared to be a tooth bud in the area of interest on the lateral cephalometric radiograph, the panoramic radiograph of the same patient was examined to confirm the presence of the tooth bud or tooth buds.

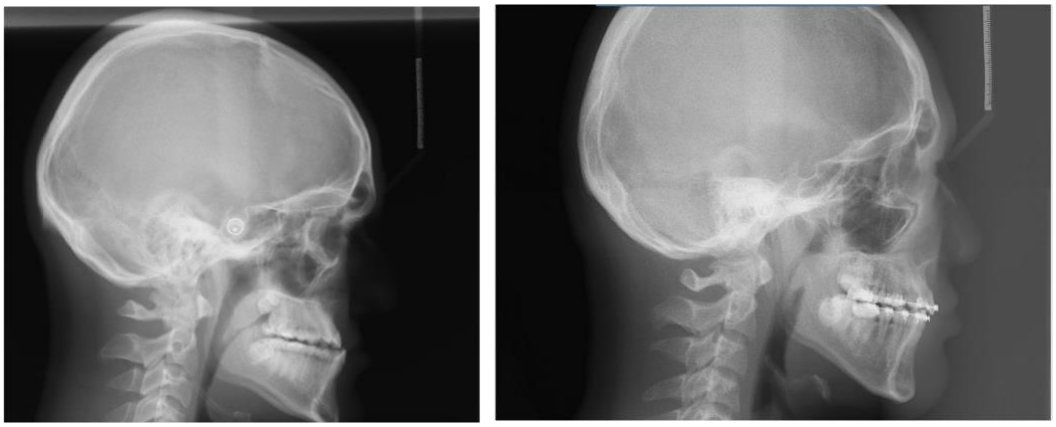

Figure 1 Example of two subjects with ITH in this study

Figure 2 Example of a subject without ITH in this study. Tooth buds for third molars are evident on the lateral cephalometric radiograph.

3.3 Statistical Analysis

Chi square test was performed to determine the significance of difference in ITH prevalence between the different groups. A p value of less than 0.05 was considered statistically significant. Previous studies have shown that males are more likely to have cleft lip with or without cleft palate whereas females are more likely to have cleft palate only (Barbosa Martelli et al. 2012; Pool et al. 2021). Also, nasal airway volume has been found to increase significantly as the age of a patient increases (Starbuck et al. 2014). Therefore, multivariable regression analysis was used to adjust for age and gender, the potential confounding factors.

Ten percent of the samples from each category was re-examined 2 weeks after the initial examination to determine the presence or absence of ITH. Kappa test was performed to determine

the intra-rater reliability. According to Cohen (1960), a Kappa score of 0.01-0.20 is considered as none to slight agreement, 0.21-0.40 as fair agreement, 0.41-0.60 as moderate agreement, 0.61-0.80 as substantial agreement and 0.81-1.00 as almost perfect agreement.

All of the statistical analyses were performed using the Stata SE software (version 17; StataCorp LLC, College Station, Texas).

4.0 Results

The demographic information of the subjects included in this study was shown in Table 1. After initial application of the inclusion criteria, 86 patients with BCLP, 184 patients with UCLP and 245 patients with SMCP were selected. However, some of the qualified subjects did not have lateral cephalometric radiographs available and were excluded. As a result, a total number of 150 cleft patients from CHP were included in the study. The 101 subjects from the Bolton-Brush study available on the AAOF website were all included.

Table 1 Demographic Information of the Included Subjects

Group	Male	Female	Average Age
BCLP	27	15	12.97
UCLP	48	33	14.24
SMCP	10	14	14.02
AAOF	58	44	15.64
Total	143	106	

After re-examination of 10% of the samples, 86.8% of the results were in agreement with the results from the initial examination. The kappa score was 0.71, which indicated substantial agreement.

The prevalence of ITH in subjects with cleft was shown in Table 2. The prevalence of ITH was the highest in the BCLP group and the lowest in the SMCP group. The prevalence of ITH was not significantly different among the BCLP, UCLP and SMCP groups (p = 0.30). The difference was not statistically significant after adjusting for age and gender (p = 0.35). After adjusting for confounders, compared to the BCLP group, the odds ratio of developing ITH in the SMCP group was 0.40, and the odds ratio of developing ITH in the UCLP group was 0.79.

Table 2 Prevalence of ITH in the BCLP, UCLP and SMCP

group	ITH present	ITH absent	Total	prevalence of ITH (%)
BCLP	18	24	43	42.9
UCLP	32	49	83	39.5
SMCP	6	18	24	25
Total	56	91	147	38.1

The prevalence of ITH in patients with complete cleft and the healthy controls was shown in Table 3. ITH was significantly more prevalent in patients with complete cleft lip and palate, i.e. BCLP and UCLP, than in the AAOF control group (OR = 1.94, 95% CI [1.10, 3.43]). This difference remained statistically significant after adjusting for age and gender, (OR = 2.29, 95% CI [1.24, 4.25]). The odds ratio of ITH increased from 1.94 to 2.29 after adjusting for the potential confounders.

Table 3 Prevalence of ITH in subjects with complete cleft (BCLP and UCLP) and the AAOF group

group	ITH present	ITH absent	prevalence of ITH (%)
complete cleft	51	75	40.5
AAOF	27	74	26.7

5.0 Discussion

ITH on the noncleft side in patients with UCLP has been consistently observed and well-described (Yan et al. 2021; Dentino, Sierra-Vasquez, and Padwa 2016; Pinto et al. 2018; Wetmore 1992). Our study showed that the odds of ITH in patients with BCLP were 1.35 times as in patients with UCLP and 2.27 times as in patients with SMCP. The difference in prevalence of ITH among the three groups was not statistically significant before and after adjusting for the potential confounders. Current literature has shown that the development of compensatory ITH is related to nasal septum deviation and increased nasal airflow on the unobstructed side (Chiesa Estomba et al. 2015; Aslan et al. 2013; Farmer and Eccles 2006; Sharhan et al. 2018). Starbuck et al. (2014) showed that the absolute amount of septal deviation and the total anterior nasal airway volume are similar in BCLP and UCLP. The findings by Starbuck et al might explain our observation that prevalence of ITH did not differ significantly among patients with BCLP and UCLP.

During recent years, early septoplasty has been recommended by some studies for patients with UCLP to improve esthetics and function (Gosla-Reddy et al. 2011; Pinto et al. 2018; Raghavan and Carr 2022). Gosla-Reddy et al. (2011) found that compared to patients who only received primary lip repair, patients underwent septoplasty during the primary lip repair before one year of age had better nasal symmetry at the two-year recall. Pinto et al. (2018) demonstrated that early rhinoseptoplasty significantly reduced the size of hypertrophied inferior turbinate in patients with UCLP at the five-year recall. However, current literature has limited data on the effect of early septoplasty in patients with BCLP. The results from our study indicated that patients with BCLP have the same risk of developing ITH as patients with UCLP, if not higher. Therefore,

it might be worth it for future studies to explore the efficacy of early septoplasty in reducing ITH and improving esthetics in patients with BCLP.

The second aim of this study was to compare the prevalence of ITH in patients with complete cleft and in the healthy controls. In this study, the prevalence of ITH was significantly higher in the patients with complete cleft (40.5%) than in the AAOF subjects (26.7%). Previous studies have shown that the dimension of compensatory ITH is positively correlated to the severity of nasal septum deviation (Liu et al. 2022; Orhan et al. 2014). The prevalence and severity of nasal septum deviation have both been found to be higher in patients with CL/P than patients without CL/P (Jiang et al. 2014; Kyrkanides, Bellohusen, and Subtelny 1995; Massie et al. 2016; Sandham and Murray 1993). The finding of more prevalent ITH in patients with complete cleft in this study therefore confirms that compensatory ITH is positively associated with nasal septum deviation.

Orthodontic treatment is an indispensable component of the interdisciplinary care that patients with CLP require. Lateral cephalometric radiographs are routinely used in the orthodontic clinical settings. A previous study by Filho et al. (2001) showed that compared to nasopharyngeal endoscopy, the gold standard diagnostic test for ITH, lateral cephalometric radiographs have a high sensitivity of diagnosing ITH but may produce more false-positive diagnoses due to its relatively low specificity. However, since lateral cephalometric radiographs are easily accessible in the orthodontic setting, this radiographic modality is still a meaningful tool for orthodontists to screen patients for potential nasopharyngeal airway obstruction caused by ITH.

6.0 Limitations

Our results showed that the odds of ITH in BCLP was more than two times higher than the odds of ITH in SMCP, but this difference was not statistically significant. The SMCP group in this study only had 24 samples, which was smaller than the sample sizes of the BCLP and UCLP groups. Since SMCP usually involves less anatomical deformity, it is likely that ITH is less prevalent in patients with SMCP than in patients with complete cleft. Future studies with a larger SMCP sample and a more even sample size across the groups might be able to detect statistically significant difference in ITH between SMCP and complete cleft.

Since lateral cephalometric radiographs tend to produce more false positive results for ITH identification (Filho et al. 2001), the actual prevalence of ITH of the included subjects might have been smaller than what was shown in the results. However, since this was a comparative study, the odds ratio of ITH between the groups reported in this study should still be a close representation of the actual relative risk between the groups.

Another limitation of this study was a power analysis was not included. However, UPMC CHP is one of the larger cleft centers in the U.S. and the sample size is comparable to the published studies.

7.0 Conclusions

1. The prevalence of ITH did not differ among patients with BCLP, UCLP and SMCP
2. The odds of developing ITH in patients with BCLP were 1.26 times as the odds of ITH in patients with UCLP and 2.48 times as the odds of ITH in patients with SMCP. This difference was not statistically significant before and after adjusting for age and gender. Future studies with larger sample size are warranted to determine if a statistically significant difference in prevalence of ITH exists among the three types of clefts.
3. Patients with complete cleft are more likely to develop ITH than patients without.

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