

Correlation between nasal endoscopy and lateral cephalometric radiography in assessing adenoid size in children: a transversal study

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Research Article

Keywords: Adenoids, Mouth Breathing, Cephalometry, Airway obstruction, Pediatrics

Posted Date: August 7th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10182398/v1>

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Additional Declarations: No competing interests reported.

Abstract

Objective

To evaluate the correlation between adenoid size assessed by nasal endoscopy and lateral cephalometric radiography in children. The null hypothesis tested was that there is no correlation between nasal endoscopy and lateral cephalometric radiography in assessing adenoid size.

Methods

A retrospective cross-sectional study was conducted including 33 children aged 6–12 years who underwent both nasal endoscopy and lateral cephalometric radiography. Endoscopic images were analyzed using ImageJ software to determine the percentage of adenoid occupation relative to the nasopharyngeal space (Adenoid/Choana). Cephalometric analysis was performed using McNamara's measurements: nasopharyngeal space (NFa–NFp) and oropharyngeal space (BFa–BFp), as well as their ratio. Pearson correlation and linear regression analyses were applied ($\alpha = 0.05$).

Results

A statistically significant moderate negative correlation was found between endoscopic and cephalometric measurements ($r = -0.43$, $p = 0.013$). Stronger correlations were observed in males ($r = -0.58$) and in children aged ≥ 9 years ($r = -0.59$). No significant correlation was found between endoscopic findings and the oropharyngeal measurement alone ($r = -0.21$, $p = 0.24$). In contrast, the nasopharyngeal measurement showed a moderate correlation ($r = -0.45$, $p = 0.009$). Regression analysis demonstrated low predictive capacity ($R^2 = 0.18$).

Conclusions

The null hypothesis was rejected. Lateral cephalometric radiography shows a limited, but significant, correlation with nasal endoscopy, particularly when nasopharyngeal measurements are used. However, cephalometric radiography should be considered a complementary tool, not a substitute, for nasal endoscopy.

1. Introduction

Nasal breathing is essential for physiological respiratory function and plays a critical role in craniofacial growth and development. The nasal cavity promotes filtration, humidification, and temperature regulation of inspired air, optimizing pulmonary gas exchange [1, 2, 3, 4]. Disruption of nasal airflow, particularly during childhood, may lead to compensatory mouth breathing, which has been consistently associated with functional and morphological alterations in the craniofacial complex [1, 2].

Chronic mouth breathing is linked to muscular imbalance, altered tongue posture, and adaptive changes in facial growth patterns, including maxillary constriction, increased lower anterior facial height, and malocclusion [3, 4]. These changes may have long-term implications for both function and aesthetics, reinforcing the importance of early diagnosis and management of upper airway obstruction [1, 2, 3, 4].

Adenoid hypertrophy is one of the most common causes of upper airway obstruction in pediatric populations [5, 6]. It is frequently associated with sleep-disordered breathing, including obstructive sleep apnea (OSA), which may lead to significant systemic consequences such as impaired neurocognitive development, behavioral disorders, cardiovascular alterations, and metabolic dysfunction [5, 6, 7]. Accurate assessment of adenoid size is therefore essential for diagnosis and treatment planning.

A nasal endoscopy (NE) exam is a direct visual examination of the nasal cavity, middle meatus, sphenoethmoidal recess, and nasopharynx that is widely used to diagnose and monitor sinonasal disease [8, 9]. It is regarded as the gold standard for evaluating adenoid hypertrophy due to its ability to provide direct, dynamic, and three-dimensional visualization of the nasopharynx [8]. Also, it detects abnormalities missed by anterior rhinoscopy, complements computer tomography exams (CT), and is useful for postoperative follow-up, biopsy targeting, and assessment of mucus, polyps, edema, and anatomic variation. However, its availability may be limited in certain clinical settings, and it may be less accessible in routine orthodontic practice [9].

In contrast, lateral cephalometric radiography (LCR) is a widely used imaging modality in orthodontics diagnosis and as a screening tool for children with suspected sleep-disordered breathing, offering a non-invasive and readily available method for evaluating craniofacial structures, teeth and soft tissues, including airway dimensions [9, 10]. LCRs have been used to investigate the intramural airway spaces, tongue, soft palate, and supporting structures, such as the hyoid bone, mandible, and cervical vertebrae [10]. Cephalometric analyses have been proposed to estimate adenoid size indirectly, such as those described by McNamara and Fujioka [11, 12, 13], and its diagnostic application has been recognized by a meta-analysis in children with obstructive sleep apnea [10, 12, 13].

However, the intrinsic static nature of LCRs raises concerns about their reliability, given that there is limited exploration of this aspect, as shown by a few reports among adults and no previous study performed in children [10]. In children, upper airway and hyoid measurements on LCR showed excellent reliability, while tongue and soft palate measures were less reliable [10].

Despite the widespread use of both diagnostic methods, the degree of agreement between NE and LCR remains controversial. While some studies have reported moderate correlations, methodological differences and variability in measurement techniques limit the generalizability of findings [14, 15, 16].

Given the clinical importance of accurate airway assessment and the interdisciplinary nature of patient management, it is crucial to clarify the relationship between these diagnostic tools. In this context, LCR can act as a screening tool in patients with respiratory problems.

Therefore, the aim of this study was to evaluate the correlation between adenoid size assessed by NE and LCR. The null hypothesis tested was that there is no association between NE and LCR in assessing adenoid size.

2. Material and Methods

2.1 Study design and ethical approval

This retrospective cross-sectional study was approved by the Institutional Ethics Committee (CAAE: 70391523.0.0000.5440). Informed consent was signed for all patients and their parents.

2.2 Sample selection

A total of 102 pediatric patients were initially screened at University Hospital of the Ribeirão Preto Medical School, University of São Paulo, Brazil. After applying inclusion and exclusion criteria, 33 children aged 6–12 years were included.

Inclusion criteria:

- Age between 6 and 12 years;
- Availability of LCR;
- Availability of NE records.

Exclusion criteria:

- Absence of one of the exams;
- Time interval > 6 months between exams;
- Previous orthodontic or medical intervention within 6 months;
- Prior adenotonsillectomy between examinations;
- Syndromic conditions.

2.3 Nasal endoscopy assesment (NE)

As part of the routine protocol of the Otorhinolaryngology outpatient clinic, all newly referred patients undergo a comprehensive clinical evaluation, including nasal endoscopy, orthodontic assessment, and speech-language pathology evaluation.

NE was performed following topical nasal decongestion and local anesthesia. During the examination, the presence of septal deviation, the degree of inferior turbinate hypertrophy, and the percentage of nasopharyngeal obstruction caused by adenoid tissue were routinely assessed [8, 9]. Clinical findings

were recorded in the patients' electronic medical records, and the corresponding endoscopic videos were digitally archived.

For the present study, demographic and clinical data were retrieved from the electronic medical records, while archived endoscopic videos were used for quantitative assessment of adenoid size. For each patient, the frame providing the best visualization of the nasopharynx was selected, corresponding to the moment when the soft palate was at rest and the entire nasopharyngeal cavity could be clearly visualized.

The selected image was analyzed using ImageJ software (National Institutes of Health, Bethesda, MD, USA). The total nasopharyngeal area and the area occupied by adenoid tissue were manually delineated and measured. The percentage of adenoid occupation of the nasopharynx (Adenoid/Choana %) was calculated as the ratio between the adenoid area and the total nasopharyngeal area, multiplied by 100 (Fig. 1).

2.4 Cephalometric analysis

Within the routine workflow of the service, and during the same clinical visit as nasal endoscopy, patients are evaluated by a multidisciplinary team including a neurologist, pediatrician, immunologist, speech-language pathologist, and orthodontist. When craniofacial and/or dental alterations were identified, patients were referred for orthodontic assessment, which includes radiographic examinations, among which LCR is requested for diagnosis and treatment planning.

LCR of the patients included in this study were obtained in standardized lateral projection using the same radiographic equipment at the University Hospital of the Ribeirão Preto Medical School, University of São Paulo, Brazil, following established head positioning protocols. The images were subsequently imported into Dolphin Imaging software (Chatsworth, CA, USA). Cephalometric landmarks were first identified and digitized, after which the software was used to trace the anatomical structures of interest according to McNamara Jr.'s analysis (Fig. 2A) [11].

The following linear measurements were performed:

- **NFa–NFp**: representing nasopharyngeal dimension, measured as the linear distance from the most posterior point of the soft palate region to the posterior pharyngeal wall. This region corresponds to the anatomical location of the adenoid tissue, which may reduce the nasopharyngeal airway when hypertrophied. Reference normative values are 13 mm at 9 years of age and 14 mm at 11 years of age (Fig. 2B).
- **BFa–BFp**: representing oropharyngeal (buccopharyngeal) dimension, measured as the linear distance from the point where the posterior border of the tongue intersects the inferior border of the mandible to the posterior pharyngeal wall. Normal values are reported to range between 10 and 12 mm, regardless of age (Fig. 2B).

In addition to the individual measurements, the ratio between nasopharyngeal and oropharyngeal dimensions ($NFa-NFp / BFa-BFp$) was calculated to assess the proportional relationship between these anatomical regions.

All measurements were performed by a calibrated examiner (GCM). In 20% of patients, new measurements were performed after 2 weeks to verify intra-examiner reliability. The intraclass correlation coefficient (ICC) was calculated, demonstrating satisfactory reproducibility.

2.5 Statistical analysis

Clinical and demographic data were retrieved from the electronic medical records and included age, sex, weight, height, and body mass index (BMI). Descriptive statistics were performed for all continuous variables, expressed as mean and standard deviation.

Quantitative data obtained from NE using ImageJ software were correlated with nasopharyngeal and oropharyngeal measurements obtained from LCR. Pearson's correlation test was used to assess the relationship between variables, and linear regression analysis was performed to evaluate predictive associations between endoscopic and radiographic measurements.

The strength of correlation was classified as weak, moderate, or strong, according to established statistical criteria, and statistical significance was determined for all analyses. A significance level of 5% ($p < 0.05$) was adopted for all tests. All statistical analyses were performed using JMP software (SAS Institute Inc., version 17.0, Cary, NC, USA).

3. Results

A total of 102 potential patients were initially screened. However, after application of the inclusion and exclusion criteria, 69 were excluded due to systemic diseases or syndromes ($n = 9$), incomplete medical records ($n = 3$), absence of one or both required examinations ($n = 44$), prior adenotonsillectomy between examinations ($n = 1$), and age outside the defined range ($n = 12$) (Fig. 3). The final sample comprised 33 patients, of whom 63.6% were male and 37.4% were female, with a mean age of 8.6 ± 1.8 years.

Overall analysis demonstrated a moderate negative correlation between the NE and LCR ratios ($r = -0.43$; $p = 0.0134$), with a low coefficient of determination ($R^2 = 0.18$). Linear regression indicated that higher endoscopic adenoid obstruction values were associated with reduced nasopharyngeal space measured cephalometrically (Fig. 4).

When stratified by sex, a stronger and statistically significant correlation was observed in males ($r = -0.58$; $p = 0.0058$), whereas females showed a weak and non-significant correlation ($r = -0.0021$; $p = 0.51$) (Fig. 5).

Regarding age, no significant association was observed when treated as a continuous variable. However, when dichotomized by median age (9 years), children ≥ 9 years demonstrated a moderate and significant

correlation ($r = -0.53$; $p = 0.0201$), while those < 9 years showed a weak, non-significant correlation ($r = -0.31$; $p = 0.28$).

Analysis of individual cephalometric variables showed that the nasopharyngeal measurement (NFa–NFp) presented a significant moderate correlation with endoscopic findings ($r = -0.45$; $p = 0.0091$) (Fig. 6A). Conversely, the oropharyngeal measurement (BFa–BFp) showed no significant correlation ($r = -0.21$; $p = 0.24$) (Fig. 6B). Regression models confirmed the superior predictive value of the nasopharyngeal dimension in relation to adenoid size.

Further stratified analysis confirmed these findings, with males ($r = -0.57$; $p = 0.0070$) and children ≥ 9 years ($r = -0.59$; $p = 0.0085$) showing the strongest associations, while weaker or absent correlations were observed in females and younger children.

Although LCR measurements demonstrated moderate correlation with NE under specific conditions, NE remained the most comprehensive method for adenoid assessment due to its dynamic and three-dimensional evaluation capacity. In contrast, LCR, despite being non-invasive and widely available for orthodontic diagnosis, showed limitations inherent to its static and two-dimensional nature. Despite the disadvantages highlighted for LCR, it showed a moderate correlation with NE, especially in older patients.

Methodological limitations included variability in the time interval between examinations, a reduced final sample size, especially in females due to strict inclusion criteria and high prevalence of syndromic or craniofacial cases in the study setting, and the relatively short recruitment period.

4. Discussion

LCR is primarily a screening and orthodontic planning tool rather than a comprehensive airway evaluation method [10, 11, 12, 13, 17]. It is most useful for assessing craniofacial relationships, nasopharyngeal morphology, adenoid size, and selected sagittal airway dimensions. However, it is limited in its ability to represent airway volume and posterior airway complexity when compared with three-dimensional imaging modalities [10, 12, 13]. The intrinsic static nature of LCR raises concerns regarding their diagnostic reliability, particularly given the limited evidence addressing this issue, which is restricted mainly to adult populations, with a lack of pediatric studies [12, 13, 18, 19].

Additional criticisms relate to the acquisition conditions of LCR, which are obtained with patients in an upright position, differing from the physiological conditions of sleep [10, 13, 18, 19]. Nevertheless, previous evidence suggests that LCR may still differentiate between obstructive sleep apnea and snoring independently of head position, supporting its potential role as a screening tool [10]. Accordingly, it has been suggested that mouth-breathing children with reduced superior pharyngeal airway space on LCR should be referred for further sleep evaluation [18, 19].

The present study demonstrated a moderate correlation between NE and LCR in the assessment of adenoid size. Nevertheless, this association was insufficient to support interchangeable use of these diagnostic methods. The observed negative correlation is anatomically expected, as enlargement of adenoid tissue results in a reduction of available airway space. This finding is consistent with previous studies reporting moderate correlations between radiographic and endoscopic assessments [10, 12, 13, 18]. However, the relatively low coefficient of determination ($R^2 = 0.18$) highlights the limited predictive capacity of LCR measurements, reinforcing that statistical significance does not necessarily translate into clinical interchangeability.

Among the cephalometric parameters analyzed, the nasopharyngeal measurement (NFa–NFp) showed a stronger association with NE findings than the oropharyngeal measurement. This is anatomically plausible, since adenoid hypertrophy primarily affects the nasopharyngeal airway, whereas the oropharyngeal space is influenced by multiple additional structures, including the tongue and soft palate.

Subgroup analyses revealed stronger correlations in males and in children aged ≥ 9 years, suggesting that craniofacial growth patterns and airway maturation may influence the relationship between imaging modalities. In younger children, greater variability in growth and anatomical development—as well as the difficulty children of this age have in keeping the palate relaxed—can reduce the reliability of LCR measurements. Although, these hypotheses require further investigation.

Despite its widespread use, LCR presents inherent limitations. As a two-dimensional imaging technique, it cannot adequately represent the three-dimensional complexity of the nasopharyngeal airway and provides only static information, without capturing dynamic functional changes during respiration, swallowing, or phonation [10, 17, 18, 19]. Additionally, variability in image quality, including differences in head posture, neck position, tongue position, and patient cooperation, may further affect measurement accuracy and should be considered when interpreting results [19, 20, 21, 22].

Importantly, since this study was conducted in a hospital-based pediatric population within a multidisciplinary care setting, ideal synchronization between NE and LCR examinations was not always feasible. This reflects real-world clinical practice but may have introduced variability due to temporal differences between assessments. Additional limitations include age heterogeneity within the sample and variability in LCR quality, both of which may have influenced measurement reliability.

NE, in contrast, allows direct visualization of adenoid tissue and its relationship with adjacent structures, including the Eustachian tube and soft palate, while also enabling functional assessment of airway dynamics, mucosal characteristics, and collapsibility—features that cannot be evaluated radiographically [23, 24].

From a clinical perspective, LCR remains useful as a screening tool, particularly in orthodontic practice where it is routinely obtained. It may assist in identifying patients who require further otorhinolaryngological evaluation. However, it should not replace NE, especially in symptomatic patients or cases requiring precise diagnostic evaluation. Rather, both methods should be considered

complementary: NE provides detailed assessment of mucosal and functional airway status, while LCR offers an accessible, low-cost overview of craniofacial and airway morphology [10, 18, 19].

Overall, NE remains the gold standard for evaluation of adenoid hypertrophy, whereas LCR should be regarded as an adjunctive screening modality. Future studies with larger and prospective samples are recommended, as well as investigations incorporating advanced imaging techniques such as cone-beam computed tomography (CBCT), to further refine airway assessment strategies in pediatric populations.

5. Conclusion

The main findings of this study are as follows:

- LCR showed a significant but moderate association with NE for the assessment of adenoid size;
- Stronger agreement between the two methods was observed in male children and in those older than 9 years;
- Among the cephalometric variables evaluated, the isolated nasopharyngeal measurement demonstrated the closest correspondence with endoscopic findings;
- Although widely available and routinely used in orthodontic practice, lateral LCR lacks sufficient accuracy to replace NE and should therefore be considered a complementary diagnostic tool.

Overall, these findings support the rejection of the null hypothesis, indicating that association exist between adenoid size estimates obtained from NE and LCR.

Declarations

Funding statement

This study was financed by Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP), undergraduate research scholarship – process number 2024/04223-9.

Author Contribution

Conceptualization: G.C, A.B and G.L
Methodology: G.C, A.B, F.C, W.T and F.L
Validation: G.C, F.C, W.T and F.L
Formal analysis: G.C, G.L, F.C and F.L
Investigation: G.C and G.L
Data curation: D.M
Writing—original draft preparation: G.C, G.L, F.C and F.L
Writing—review and editing: All authors
Supervision: F.C, W.T, M.A and F.L
Funding acquisition: F.C and F.L

Data Availability

All data supporting the findings of this study are available within the paper and its Supplementary Information.

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Figures

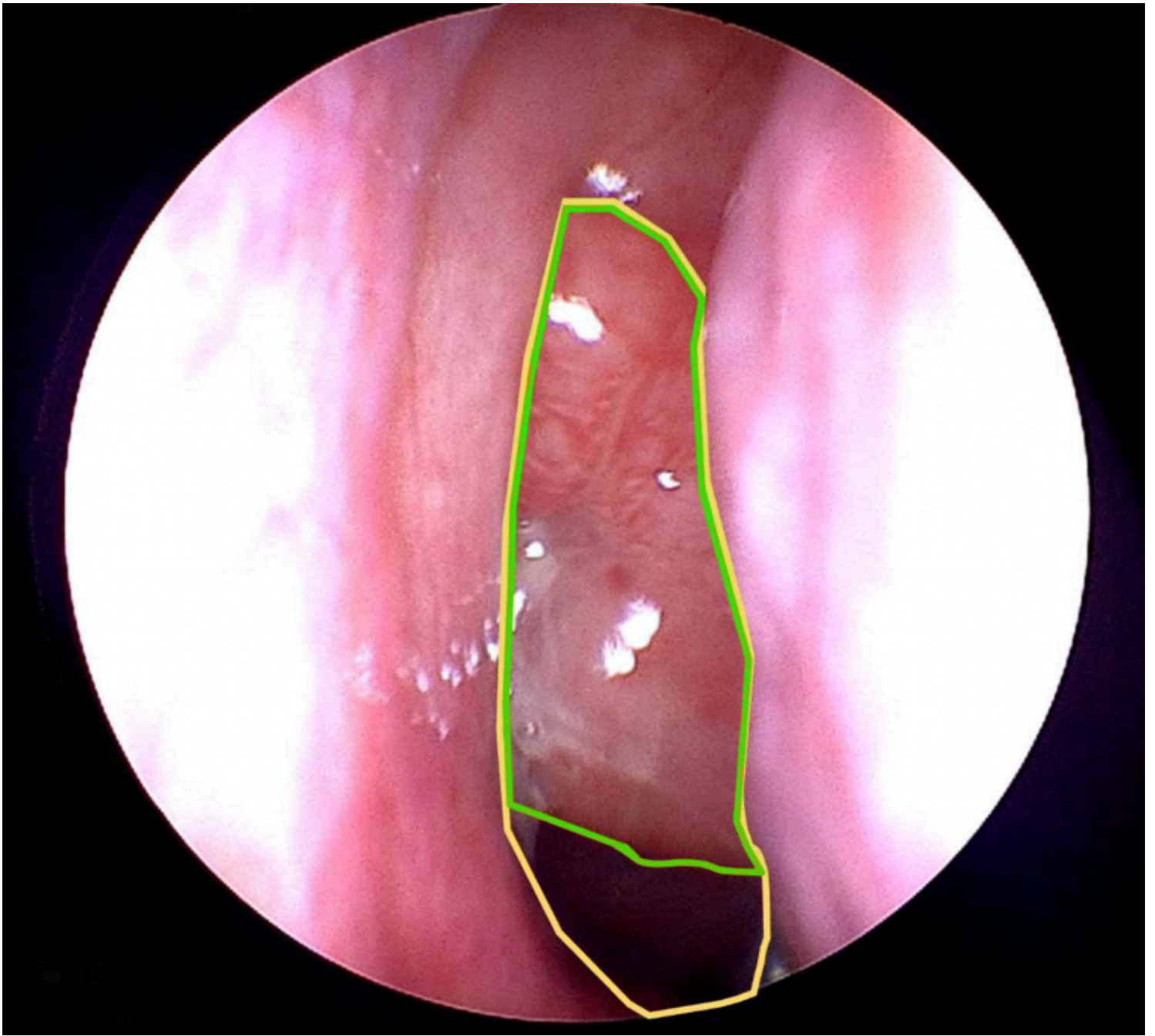


Figure 1

Nasal endoscopy (NE) submitted to analysis by ImageJ software. The nasopharynx region is delimited in yellow, and the adenoid area in green.

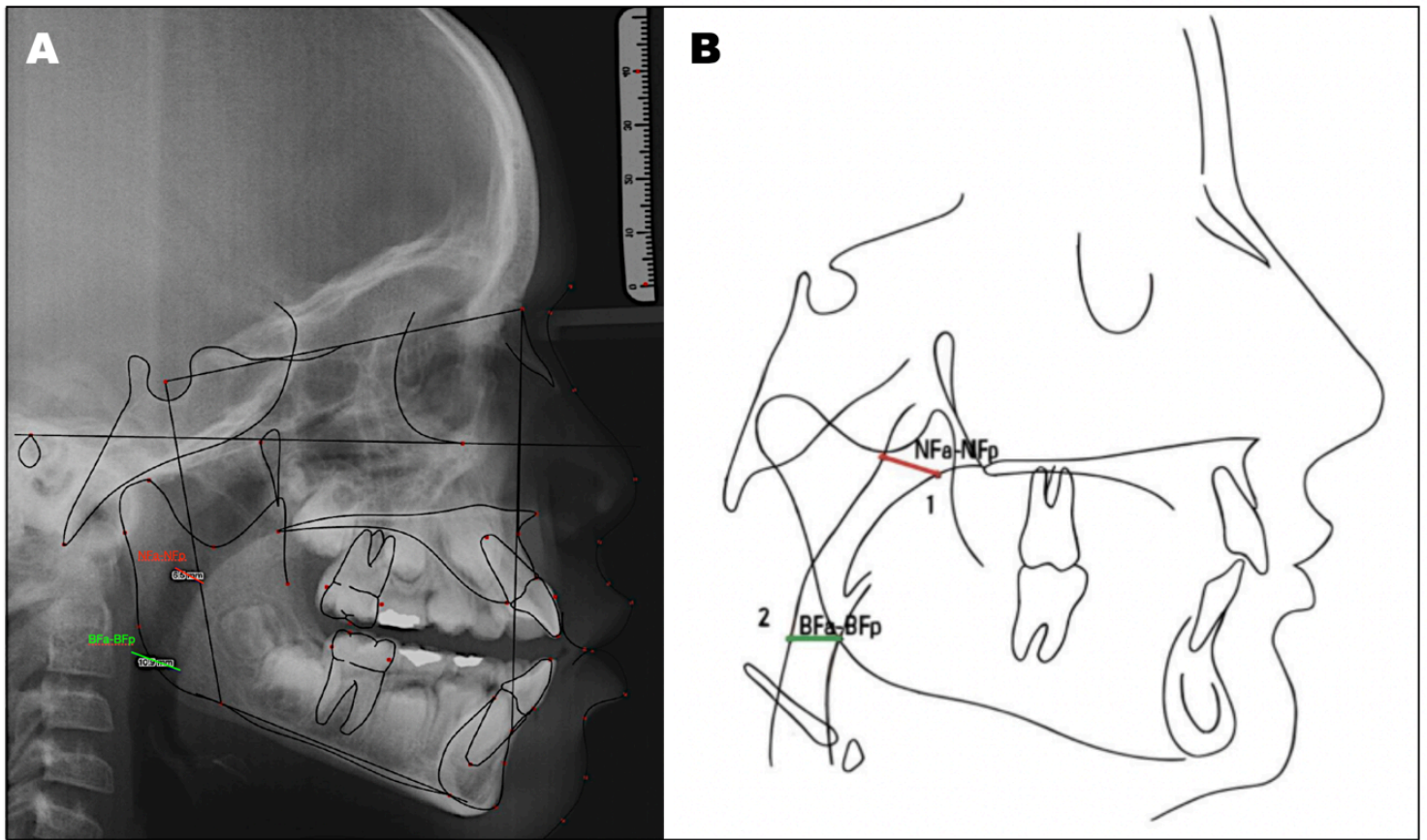


Figure 2

A- Measurement of the nasopharynx ($NFa-NFp$ - red) and oropharynx ($BFa-BFp$ - green) on lateral cephalometric radiography – LCR; B- Cephalometric tracing showing the measurements (McNamara Jr., 1984).

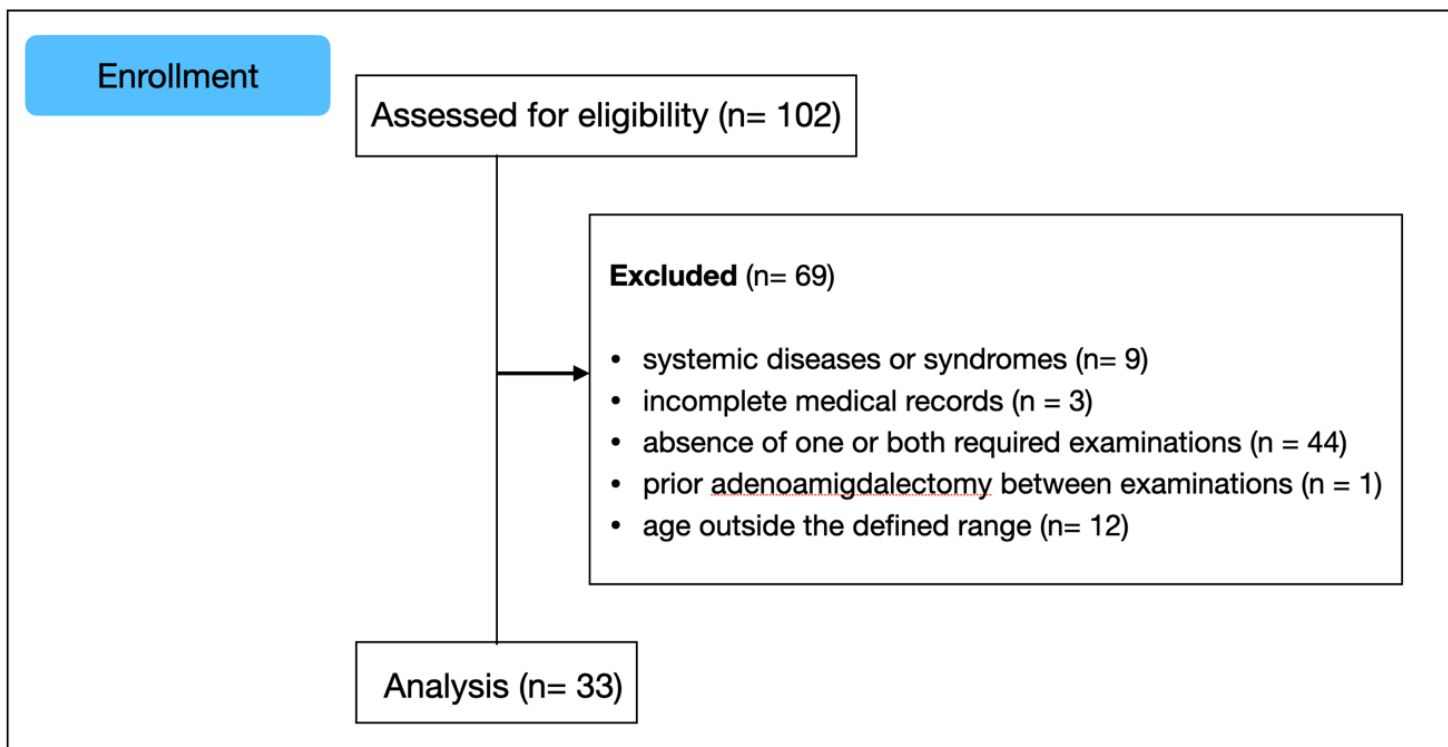


Figure 3

Study flow chart.

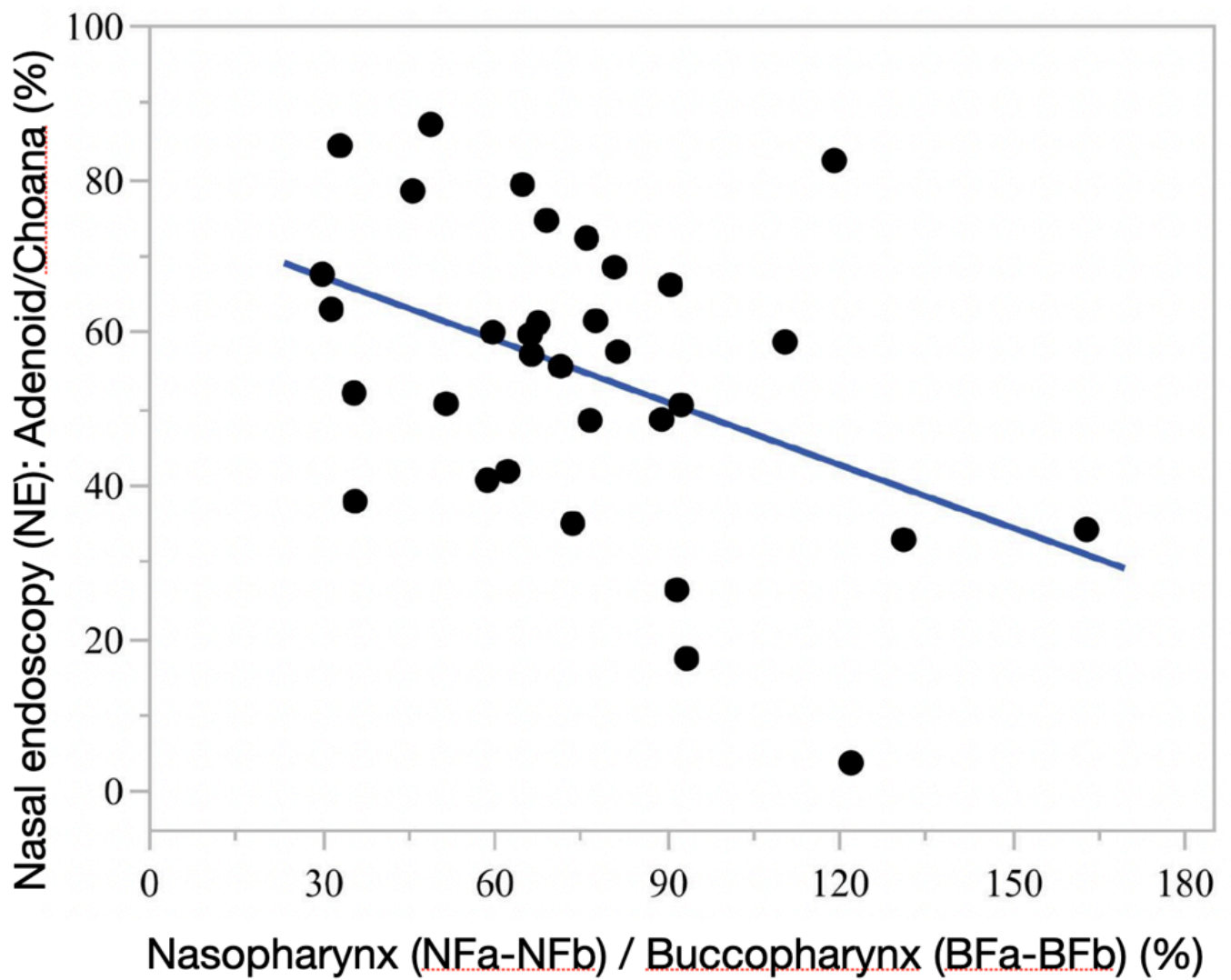


Figure 4

Correlation between Adenoid/Choana (%) in nasal endoscopy (NE) versus ratio between Nasopharynx/Buccopharynx measurements (%) (McNamara Jr., 1984) measured in lateral cephalometric radiography (LCR).

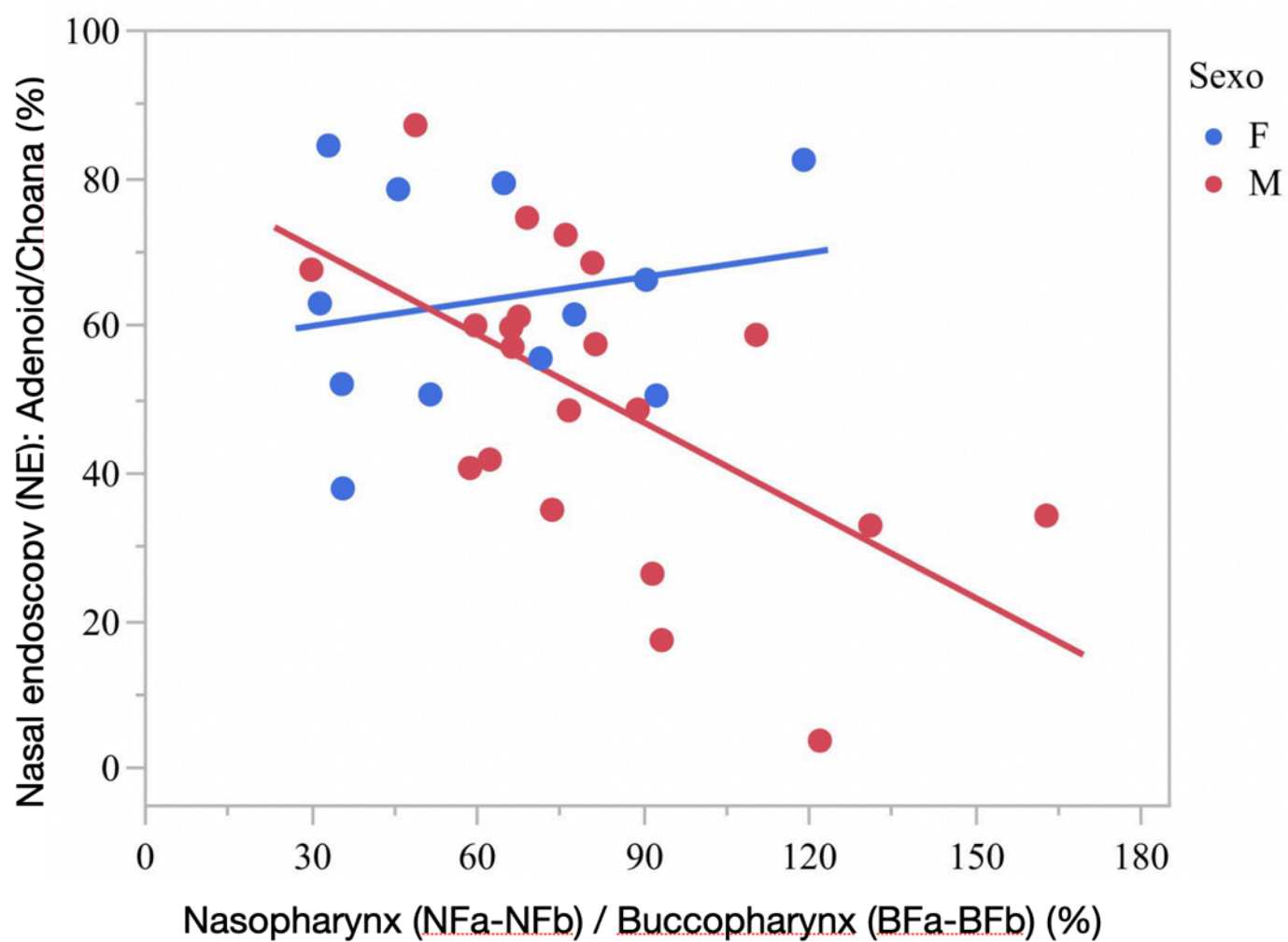


Figure 5

Correlation between Adenoid/Choana (%) in nasal endoscopy (NE) and Nasopharynx/oropharynx (%) in lateral radiographic cephalometry (LCR): difference between male (red) and female (blue) sexes.

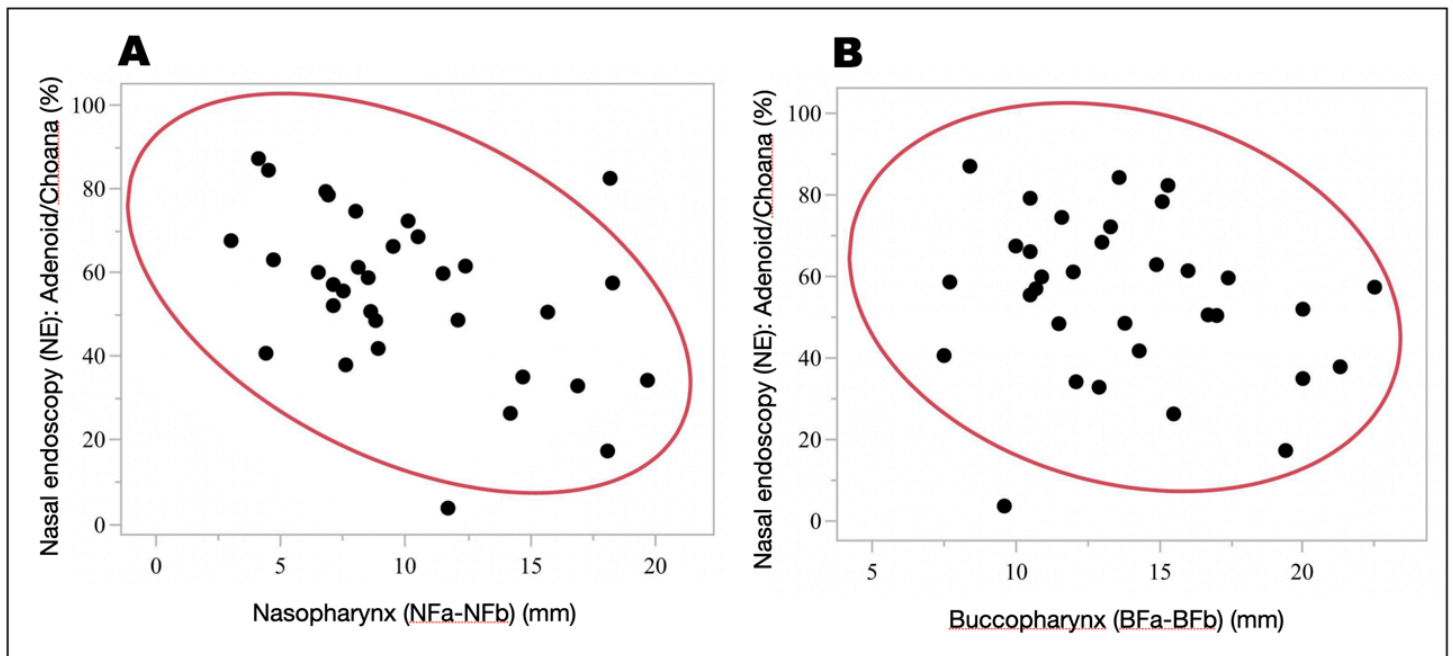


Figure 6

Correlation between the Adeno/Choana ratio (%) in nasal endoscopy (NE) versus the NFa-NFp measurement (A) and the BFa-BFb measurement (B) in lateral cephalometric radiography (LCR).