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Article

3D Stereophotogrammetry in the Evaluation of Pediatric OSAS: Preliminary Results

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Abstract: **Introduction:** Obstructive sleep apnea syndrome (OSAS) is characterized by recurrent episodes of upper airway obstruction and involves intermittent hypoxia and sleep fragmentation, with potentially serious consequences for affected patients. [1–3]. Although nocturnal polysomnography is the gold standard, it is an exam that is not readily available and is very expensive. [4]. Hence, the need to find new diagnostic methods. Considering that the causes of OSAS can be divided into anatomical-structural ones, related to craniofacial anomalies, it has been hypothesized that anthropometric measurements taken by new 3D stereophotogrammetric systems could be useful as a diagnostic tool in pediatric patients with OSAS [5,6]. The primary objective of the study is, therefore, to evaluate the correlation between mandibular length measured between menton and gonion, obtained through 3D stereophotogrammetry using the "Face Scanner maxi 6", and the severity of OSAS (AHI classification), defined by the score of the Sleep Clinical Record (SCR) questionnaire in a group of pediatric patients with suspected obstructive sleep disorders. The secondary objective concerns the identification of possible correlations between other mandibular parameters estimated by 3D stereophotogrammetry and the severity of OSAS, defined by the McGill Oximetry Score (MOS), and the association between MOS and SCR to determine the AHI level. **Materials and methods:** The study considered patients who were prescribed a pulseoximetry exam due to suspected obstructive sleep disorders. All participating patients underwent a specialized orthodontic examination, which included completing the SCR questionnaire and taking facial photographs using a 3D stereophotogrammetric system. The SCR questionnaire considers 11 dental, nasal, oropharyngeal, and facial phenotype parameters to determine a final score from 0 to 18, indicating the risk of obstructive sleep apnea syndrome. The acquired stereophotogrammetric images were processed using dedicated software to obtain a three-dimensional model representing the patient's facial phenotype. Subsequently, anatomical landmarks and relevant anthropometric measurements were identified on the model, and it was assessed whether one or more of these showed concordance criteria with the parameters derived from SCR and MOS. The anthropometric evaluation was performed by expert operators, taking into account mandibular variables. **Results:** Fifteen patients were analyzed, with 2 excluded due to alterations in the stereophotogrammetric images caused by poor patient cooperation during the acquisition of the photographs. Spearman's correlation analysis was performed to investigate the relationship between anthropometric measurements, obtained by 3D stereophotogrammetry, and OSAS severity, by means of SCR, MOS, and SCR+MOS. A significant and negative correlation was observed between right mandibular length (gonion-menton) and MOS ($\rho = -0.586$, $p = 0.036$). **Conclusions:** The result obtained has important implications for the field of study and suggests that future attention should focus more on the mandibular length variable as a determining factor for OSAS. However, the sample examined was relatively small, which might obscure the correlation with contralateral mandibular length and potential correlations with other mandibular/facial parameters. Additionally, the small sample size prevented stratification by sex and age. The study thus provides an important contribution to understanding the relationships between 3D stereophotogrammetry and pediatric OSAS but also highlights the need for further research that could potentially influence future developments in diagnosing OSAS in children.

Keywords: sleep apnea syndrome; sleep disturbance; facial morphology; orthodontic; stereophotogrammetric method

1. Introduction

Sleep medicine is a medical field that focuses on the study, diagnosis, and treatment of sleep disorders. Among these disorders are respiratory-related conditions, ranging from primary snoring to obstructive sleep apnea syndrome (OSAS). OSAS is defined as an intermittent or prolonged obstruction of the upper airways, which disrupts normal ventilation and sleep cycles. [1–3].

OSAS, particularly in children, can cause cognitive deficits and growth delays, including neurobehavioral problems, learning disorders, memory loss, and decreased academic performance [7,8].

Being considered a multifactorial condition, OSAS is associated with various risk factors, including adenotonsillar hypertrophy, obesity, and skeletal anomalies (such as midface hypoplasia and microretrognathia) [9].

Currently, the diagnosis of this condition is made using polysomnography (PSG), an examination that monitors various physiological parameters during sleep. This instrumental investigation is performed only in specific cases based on already manifested symptoms and allows the condition to be classified as mild, moderate, or severe [4]. The high costs, limited practicality, and invasiveness of this examination for the pediatric population have led to the search for new alternative diagnostic methods. Home polysomnography and respiratory polygraphy (RP) are viable alternatives when in-hospital PSG is not available, but the new diagnostic frontier increasingly seems to be oriented towards new tools [10]. Among these tools is the Sleep Clinical Record (SCR), a questionnaire that includes a series of questions evaluating various aspects of sleep and associated symptoms, such as snoring, observed apneas, daytime sleepiness, sleep behavior, and other clinical factors to gather useful information to determine the likelihood and severity of OSAS. Another method is based on the analysis of data obtained from nocturnal pulse oximetry, particularly the McGill Oximetry Score (MOS), which classifies the severity of the disease into different categories based on the severity of oxygen desaturations and observed saturation patterns [10,11].

Finally, there are optical detection methods such as 3D stereophotogrammetry, which investigates the craniofacial phenotypic characteristics typical of OSAS [5,6].

3D stereophotogrammetry has several advantages, including non-invasiveness as there is no use of X-rays, minimal operator-patient contact, and rapid data acquisition, making it suitable even for uncooperative patients such as pediatric ones [5].

To set up the research protocol for this study, a narrative review was initially conducted with the aim of evaluating 3D stereophotogrammetry as a sensitive and specific means to diagnose the presence and severity of obstructive sleep apnea syndrome (OSAS). The search was performed on PUBMED bibliographic database without time or language restrictions.

Out of 26 studies reviewed, 7 demonstrated a correlation between OSAS severity and various anthropometric parameters assessable through 3D stereophotogrammetry. Specifically, these parameters included submandibular fat deposition, neck circumference, body mass index, facial convexity, mandibular length angle (Mwla), mandibular width (Mw), mandibular depth (Md), neck perimeter, area of the cranial base triangle, volume of the middle cranial fossa, facial width, neck width, inter-eyebrow width, mandibular length, and maxillary volume.

However, two studies indicated that facial analysis based on 3D stereophotogrammetry does not appear to be predictive for screening pediatric OSA because age and body mass index likely modify the effect of soft tissue facial characteristics and craniofacial anomalies, as risk factors for OSA in children [16–22].

Based on this analysis, it has also been noted that there is currently limited scientific literature available on this topic. Therefore, it was decided to further explore the use of 3D stereophotogrammetry for diagnosing OSAS in children by setting up a research protocol that involves enrolling 150 pediatric patients (aged 2–14 years) suspected of having OSAS.

The aim of the present study is to investigate potential correlations between stereophotogrammetric measurements and traditional methods of OSAS diagnosis.

In particular, the primary objective is to assess the relationship between the presence and severity of OSAS (classified by AHI score), defined by the SCR questionnaire score, and the mandibular length between mentum and gonion measured by 3D stereophotogrammetry in children.

The secondary aim of the present study is the investigation of potential correlations between mandibular width (defined between right gonion and left gonion), mandibular depth (determined

by the line orthogonal to mandibular width passing through mentum), mandibular length angle (as the angle between right gonion, mentum, and left gonion), mandibular area (included by right gonion, mentum and left gonion) estimated from 3D stereophotogrammetry and the severity of OSAS, defined by SCR, MOS scores and by a composite index including both, SCR and MOS.

2. Materials and Methods

Study Population and Setting

The present work includes the preliminary results of a study still on-going and approved by local Ethical Committee (CE AVEN ID: "659/2023/SPER/UNIPR ID SIRER 6785 SONNO01). Pediatric patients suspected of having obstructive sleep disorders will be considered, comparing data obtained from overnight pulse oximetry and sleep disorder questionnaire with results from 3D stereophotogrammetric facial anthropometric examination.

The study is conducted through collaboration between the University Dentistry Center - Department of Medicine and Surgery - University of Parma and Pediatric Respiratory Pathophysiology Clinic, University Hospital of Parma. Specifically, these subjects undergo a pulse oximetry, for suspected obstructive sleep disorders, which is assessed and reported by pediatric specialists. At the end of this procedure, office operators will inform the legal parents/guardians of eligible patients about the possibility of participating in the aforementioned study for free.

Enrollment in the study sample will take place at the University of Parma Dentistry Center, including 130 patients aged between two and fourteen years with suspected OSAS. As standard clinical practice, patients suspected of having obstructive sleep disorders underwent a specialist visit at the Pediatric Respiratory Pathophysiology Clinic of the University Hospital of Parma. The SCR questionnaire was administered, and the main parameters from the overnight pulse oximetry examination were evaluated. Subsequently, patients who agree to participate in the study were referred to the Dentistry Center of the University of Parma.

An orthodontic specialist examination was performed, gathering information on age, sex, weight, BMI, dentition phase, Angle skeletal class, dental malocclusion, overjet, overbite, breathing pattern (oral or nasal), lip seal (competent or incompetent), and lip tone (normal or hypotonic). Additionally, the Glatzel test and Rosenthal test will be performed and anthropometric measurements through 3D stereophotogrammetry were recorded.

This methodology uses the acquisition of pairs of frames taken from different angles to create a three-dimensional reconstruction of the face. Anthropometric measurements such as distances, areas, angles, and volumes can be performed on this 3D model. This completely passive system utilizes reflected light without interfering with subjects, making it similar to traditional photography [12].

To capture the images, the patient is seated on an adjustable stool positioned one meter away from the cameras. The instruments are calibrated, and the subject is instructed to assume a neutral expression and relaxed posture. Using a remote control tool, the operator takes the photos, which are then processed by a computer equipped with photogrammetric software.

At this stage, it will be the responsibility of an experienced tracker to examine the relationships between anatomical points of interest according to research objectives [6,13–15].

Inclusion criteria were: (a) patients aged between two and fourteen years; (b) patients with suspected respiratory sleep disorder who have undergone overnight pulse oximetry for suspected OSAS; (c) parental or legal guardian's adherence to and signing of informed consent. Exclusion criteria were: (a) patients diagnosed with conditions such as Down syndrome, Prader-Willi syndrome, Hunter syndrome, Hurler syndrome, achondroplasia, and all other conditions that may lead to severe craniofacial anomalies; (b) patients currently undergoing orthodontic treatment or who have undergone orthodontic treatment in the past; (c) patients without a legal guardian or with a legal guardian belonging to vulnerable categories or incapable of understanding and giving consent (individuals who, due to age or clinical condition, are unable to receive information and give consent).

3D Stereophotogrammetry

Facial images of each subject will be acquired using the "Face Shape 3D Maxi Line Photogrammetric Scanner" device (Polishape 3D Srl, Bari, Italy). This stereophotogrammetric system consists of 6 Canon EOS 1100D digital reflex cameras assembled together on a rectangular support.

The face will be uniformly and adequately illuminated by two synchronized flashes positioned on both sides of the cameras, ensuring that any other light source is absent. An adjustable stool will be placed one meter away so that the subject's eyes are at the same level as the central upper camera. A monochromatic "chroma-key" panel will be placed behind the subject to facilitate image acquisition. Once the subject is seated on the stool, the instruments will be calibrated, and then the images will be acquired: the subject will be asked to assume a neutral expression and a relaxed posture. The images will be captured by the operator using a remote control device connected to the computer via a USB cable. After pressing the button, 6 photographs will be taken simultaneously. The procedure will be repeated as necessary until satisfactory shots are obtained.

The 3D image processing will be performed using DELTA-MED software. Each image will be manually refined by eliminating peripheral areas such as hairline, ears, neck, and shoulders, as these areas are prone to errors. The images will then be oriented so that the bipupillary line is parallel to the horizon and fixed in this position. Subsequently, anatomical landmark points of interest mentioned earlier will be identified on the stereophotograph. Specifically, measurements in millimeters (mm) will be used for mandibular width, right and left mandibular length, and mandibular depth. Mandibular depth angle will be measured in degrees ($^{\circ}$), and mandibular area will be measured in square millimeters (mm^2) [23].

OSAS Identification

Presence and severity of OSAS is defined by the AHI classification, and based on the score of the Sleep Clinical Record (SCR) and the McGill Oximetry Score (MOS) [10,11]. SCR considers 11 parameters including nasal septum deviation, nasal obstruction, mouth breathing, tonsillar hypertrophy, palate position according to Friedman classification, dental/skeletal malocclusion, narrow palate, phenotype, presence of attention deficit and hyperactivity symptoms, presence of other symptoms, and Brouillette score, resulting in a final composite score ranging from 0-18 to define the AHI value. SCR classifies absence ($\text{SCR} < 6,5$), mild ($6,5 \leq \text{SCR} < 8,25$) and severe ($\text{SCR} \geq 8,25$) OSAS. MOS method identifies absence and presence of OSAS when the score is ≤ 1 and > 1 , respectively.

To comprehend both approaches, we considered a composite index including SCR and MOS with the following classification: $\text{SCR} < 6,5 + \text{MOS} \leq 1$ as absence of OSAS, $\text{SCR} \geq 6,5 + \text{MOS} = 1$ as mild OSAS, and $\text{SCR} \geq 6,5 + \text{MOS} > 1$ as severe OSAS.

Statistical Analysis

The sample size estimation was based on the study published by Lin et al. [20], which reported a significant correlation between mandibular length and the severity of the pathology according to the AHI classification ($r=0.44$, $p=0.01$). Fifty-four subjects achieve a statistical power of 91% to detect a Pearson correlation of 0.44 using a two-tailed hypothesis test with a significance level of 0.05. These results are derived from a Monte Carlo simulation of 5,000 samples drawn from a bivariate normal distribution under the alternative hypothesis (PASS 2020 Power Analysis and Sample Size Software, 2020, NCSS, LLC. Kaysville, Utah, USA, ncss.com/software/pass). Considering a 20% dropout rate, the study will enroll 65 patients.

Categorical variables are expressed as percentages, continuous variables as mean $\pm$ standard deviation or median [interquartile range], according to data distribution, assessed by Shapiro-Wilk and Kolmogorov-Smirnov tests.

The correlation between mandibular length (me-go), mandibular width between the right and left gonions (gor-gol), mandibular depth, mandibular length angle, mandibular area defined by the right gonion, mentum, left gonion, and mandibular width, and the severity of OSAS (SCR, MOS, $\text{SCR} + \text{MOS}$) will be analyzed using Spearman's correlation analysis.

Statistical analysis was performed with SPSS (v28.0 for Windows, SPSS Inc., Chicago, IL, USA). A p-value < 0.05 was considered statistically significant.

3. Results

At the moment, the enrollment status includes 15 patients were evaluated over a period of approximately two months. For 2 out of the 15 recruited patients, the anthropometric measurements related to mandibular width, right and left mandibular length, mandibular depth, mandibular depth

angle, and mandibular area were deemed unreliable. Therefore, these parameters were not included in the statistical analysis.

The sample includes 7 were male and 8 were female, accounting for 46.7% and 53.3%, respectively. Regarding BMI percentiles, 12 children (80%) were normal weight, 1 (6.7%) was at risk of overweight, and 2 (13.3%) were overweight.

Regarding tonsillar hypertrophy, 9 (60%) tested negative, while 6 (40%) tested positive.

Considering SCR questionnaire results, it was found that 46.7% (7 patients) was classified as healthy subjects, 13.3% (2 patients) as mild OSAS, and 40% (6 patients) as patients with severe OSAS.

The pulse oximetry examination revealed that 11 patients (73%) were not affected by OSAS and 4 (27%) tested positive the clinical condition.

Finally, considering the composite index, SCR+MOS, it was observed that 46.7% were not affected by OSAS, same percentage of subjects was classified as mild OSAS patients, and only 6.7% was described by severe OSAS.

Table 1. Clinical characteristics and anthropometric measurements by 3D stereophoto of subjects enrolled in the study (n=15).

Variables	mean±sd, median [Q1-Q3]
Sex (F%/M%)	46.7%/53.3%
Age (months)	74.7±18.1
BMI (kg/m²)	15.5 [15.3-16.2]
Gor-Gol (mm)	107.7±6.2
Gol-Me (mm)	79.5±5.7
Gor-Me (mm)	79.8±4.1
Md (mm)	58.5±4.2
Gor-Me-Gol (angle, °)	85.1±4.8
Gor-Me-Gol (area, mm²)	3083.5±383.3

The relationship between anthropometric measurements of 3D stereophotogrametry and severity of OSAS was investigated through Spearman's correlation analysis (Spearman's Rho, ρ). A significant and negative relationship was described between MOS score and right mandibular length (ρ : -0.586, p : 0.036, Table 2).

Table 2. Relationship between severity of OSAS and anthropometric measurements.

	Gor-Gol (mm)	Gol-Me (mm)	Gor-Me (mm)	Md (mm)	Gor-Me-Gol (°)	Gor-Me-Gol (mm²)
SCR	ρ : 0.128 p : 0.676	ρ : 0.15 p : 0.625	ρ : -0.193 p : 0.528	ρ : 0.064 p : 0.835	ρ : -0.171 p : 0.576	ρ : 0.043 p : 0.89
MOS	ρ : -0.293 p : 0.332	ρ : -0.146 p : 0.633	ρ: -0.586 p: 0.036	ρ : -0.195 p : 0.523	ρ : 0.098 p : 0.751	ρ : -0.244 p : 0.422
SCR+MOS	ρ : 0.082 p : 0.789	ρ : 0.165 p : 0.59	ρ : -0.206 p : 0.499	ρ : 0.124 p : 0.687	ρ : -0.206 p : 0.499	ρ : 0.082 p : 0.789

4. Discussion

The present work describes preliminary results of a study investigating the potential clinical application of a 3D stereophotogrammetry to identify pediatric patients affected by OSAS. A significant and negative relationship was observed between McGill Oximetry Score (MOS) and right mandibular length ($r=-0.586$, $p=0.036$), suggesting that anthropometric measurements obtained by the novel approach may potentially be useful in future clinical applications.

Reduced mandibular length is certainly correlated with reduced airway ventilation space and, consequently, a higher likelihood of more frequent and severe desaturations during sleep, leading to an elevated MOS value in pulse oximetry exams.

Comparing this result with the current literature, we can find some agreements but also discrepancies.

As Collier argues, there is a significant inverse relationship between mandibular length and the severity of OSA in male patients. This means that shorter (or retruded) mandibles are associated with more severe forms of OSA. In female patients, the relationship is opposite: longer mandibles are associated with more severe forms of OSA. This discrepancy between genders could be due to the fact that females in the sample had a higher body mass index (BMI)[21].

According to Ohmura's study, mandibular length shows a significant negative correlation with OSAS in non-obese groups ($R=-0.50$, $P<0.05$), but not in obese individuals. Furthermore, it does not show significant correlations with AHI when stratified by gender. [16]

Other parameters, including mandibular length angle, mandibular width, and mandibular depth, have shown an increase associated with an increase in the severity of OSAS.

Comparing with Lin's study, however, the parameter mandibular length shows a positive correlation with the severity of OSAS; as one increases, so does the other. [20]

However, it is important to note that the discrepancies in the results compared to those of Lin, Ohmura, and Collier are likely due to the small sample size and, importantly, the different age range: pediatric patients considered in this study may not be comparable to the adult population studied in previous literature.

Children go through rapid growth periods, especially during infancy and puberty, which result in significant changes in the size and shape of craniofacial structures. In contrast, adults have completed their bone development, and craniofacial dimensions remain relatively stable. Additionally, the head-to-body proportions are different in children compared to adults, with the head being relatively larger in proportion to the body, and the airways being smaller and narrower in children than in adults. This makes children more susceptible to obstruction. The growth and development of craniofacial structures, such as the jaw and mandible, influence the size and shape of the upper airways.

Comparing these results with studies conducted on the pediatric/adolescent population by Fernandes Fagundes, significant differences are noted. In his 2022 study, he examined the effectiveness of 3D facial stereophotogrammetry as a screening method for pediatric obstructive sleep apnea. 3D stereophotogrammetry, either alone or combined with other tools such as questionnaires and craniofacial indices, was not predictive for screening pediatric OSA. [19]

Shortly thereafter, in another study in 2023, Fernandes Fagundes concluded that 3D stereophotogrammetric analysis is not useful for identifying distinct phenotypes of pediatric OSA based solely on soft tissue facial characteristics or craniofacial anomalies. [18]

Age and body mass index (BMI) likely modify the effect of facial soft tissue characteristics and craniofacial anomalies as risk factors for pediatric OSA. Consequently, from this initial result of our study, stereophotogrammetry appears to have good diagnostic potential to predict, based solely on anthropometric analysis, a facial phenotype more or less associated with mild, moderate, or severe OSA, contrary to Fernandes Fagundes' findings.

However, this study has several critical considerations. Firstly, it is important to note that these results are currently partial, and thus it will be necessary to recruit a substantial number of patients in the future to confirm or highlight further significant correlations. The small sample size of the current study also prevented stratification of results by gender, which is a definite limitation. As demonstrated by Collier in existing literature, there are indeed differences between male and female samples regarding anthropometric analysis of soft tissues. [21]

The same applies to age stratification: in a population ranging from two to fourteen years old, it is not possible to neglect the dimensional difference in absolute terms of craniofacial structures, such as the mandible.

Also to be considered is that the growth of craniofacial structures presents a different gradient based on sex and age. Female growth peaks earlier and faster compared to males, being more progressive and enduring over time. For both sexes, growth of the cranial vault halts around 4-5 years old, while more caudal structures such as the maxilla and mandible continue to grow. Around the pubertal period, the maxilla begins to halt its growth while the mandible continues until reaching adulthood, which occurs slightly earlier in females compared to males [24,25].

This means inevitably that age stratification is indispensable for obtaining valid results not distorted by the different growth phases of subjects.

Another critical aspect concerns the fact that current results have shown a negative correlation between the MOS and right mandibular length but not left. This is most likely again linked to the reduced sample size, as unless there are patients with specific facial asymmetries, right mandibular length should overlap with that of the left in the general population.

The presence of some confounding factors such as BMI expressed in percentiles and palatal tonsillar hypertrophy is confirmed. Certainly, the presence of a modest bucco-submandibular adipose tissue influences the presence of obstructive sleep apnea, as it tends to compress the upper airways, reducing airflow, as supported by Banabilh [17]. However, patients considered overweight should be excluded from the analysis because inevitably, the accumulation of fat in the facial region interferes with the identification of correct facial anthropometric points. Consequently, the soft tissue mask does not follow the contours of the underlying bone structures but is altered instead.

Palatal tonsillar hypertrophy is also considerable as a confounding factor. It's evident that due to the development of the lymphatic system and initial contact with environmental pathogens, palatal tonsils can enlarge in response to infection. This process is common in the pediatric population and is typically self-limiting over time, often resolving without invasive interventions in most cases. For those with particularly severe hypertrophy leading to conditions like kissing tonsils, there is inevitably a reduction in the ventilatory space necessary for normal breathing, increasing the likelihood of obstructive sleep apnea (OSA). This factor significantly affects the results of pulse oximetry and the SCR questionnaire. In severe cases of tonsillar hypertrophy, it cannot be excluded that OSA is primarily attributable to this factor rather than specific craniofacial conformations.

It is also suggested to include adenotonsillar hypertrophy as a confounding factor. This parameter is evaluated only in patients undergoing specialist otolaryngological examination, typically including nasal fibroscopy. For obvious reasons, it is not routinely performed on all patients suspected of OSA but is generally reserved for those diagnosed with severe OSA. Nevertheless, if such investigations were conducted, it would be beneficial to specify this in the data collection database to consider in future statistical analyses.

Further consideration should be given regarding the use of the equipment itself. Out of 15 analyzed patients, 2 were excluded due to unsuccessful stereophotogrammetric image capture.

This is due to three main reasons:

- Greater difficulty for pediatric patients compared to adults in maintaining the correct posture. Often, multiple shots are necessary, and the subject may become tired and less likely to hold the required position. This establishes a vicious cycle that inevitably requires a break before repeating the acquisition process, thus extending the time needed for the examination to succeed.
- It is necessary to have an adjustable stool that can vary greatly in terms of seating height. This is because, considering an age range from two to fourteen years old, the height of patients can vary significantly compared to the variation seen in an adult population.
- Often, it is necessary to actively involve the child in the shooting process, reassuring them and making the examination appear comparable to a playful activity in their eyes. This approach has been found to increase participation willingness and consequently reduce failures in the acquisition process.

5. Conclusions

In this study, we explored the preliminary results of an on-going project which investigates the potential effectiveness of 3D stereophotogrammetry as a diagnostic tool for obstructive sleep apnea in the pediatric population.

The main results highlighted that the right mandibular length variable (gonion-menton) shows a significant negative correlation with the McGill Oximetry score. This initial result has important implications for the field of study, suggesting that future attention should focus more on the mandibular length variable as a determining factor for OSAS.

However, there are limitations. First, the sample size was relatively small, which could obscure the correlation with left mandibular length and potential correlations with other mandibular parameters. Additionally, the small sample size prevented stratification by sex and age.

Confounding factors such as palatine tonsillar hypertrophy and BMI (percentiles) were confirmed, and a new confounding factor, adenotonsillar hypertrophy, was identified and should be considered.

It is suggested to continue this line of research to confirm the results obtained so far, but more importantly, to expand the correlations highlighted not only with the MOS index but also with the SCR questionnaire or the evaluation through SCR combined with MOS.

For this reason, it is necessary to extend the range of anthropometric variables considered, not limiting to the mandibular region alone. Other areas hypothesized to have correlations with OSAS could be identified in the nasal and maxillary regions. Some examples include: [26–28]:

- Nostril Width: The maximum distance between the two sides of the nostrils.
- Nasal Length: The distance from the root of the nose (nasion) to the tip of the nose (pronasale).
- Nasolabial Angle: The angle formed between the columella of the nose and the upper lip.
- Columellar Length: The distance from the subnasal point to the lower point of the columella.
- Nasal Index: The ratio of nasal width to nasal length, multiplied by 100.
- Facial Width: The distance between the right and left tragus.
- Bizygomatic Width: The line connecting the right and left zygions.

In conclusion, this study provides a significant contribution to understanding the relationships between 3D stereophotogrammetry and pediatric OSAS. However, current knowledge in this regard remains very limited, and therefore, these initial findings should pave the way for further research that could have significant practical applications in diagnosing obstructive sleep apnea in the pediatric population.

Author Contributions: Antonio Sant Agostini: Methodology, Writing – review & editing. Benedetta Vaienti: Writing – review & editing. Christian Longhi: Writing – original draft. Marco Di Blasio: Writing – review & editing. Marzia Segu: Supervision, Writing – review & editing. Sara Tagliaferri: data analysis, data curation, Writing – review & editing.

Conflicts of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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