Changes in dentofacial development in tracheostomized pediatric patients

Original Article

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Abstract

Considering the known impact of the absence of nasal flow on dentalfacial growth, tracheotomy should be considered to have a negative impact in pediatric age. The aim of this study is to caracterize the dentofacial development in a population of tracheostomized children. A sample of 29 patients was obtained, and frontal, profile and intra-oral dental photographs taken, and analysed by a stomatologist. The median age at which tracheotomy was performed was 3 months old. The underlying reason was due to superior airway obstruction (SAO) 38%, low respiratory failure/prolonged ventilation (LRF/PV) in 31%, and syndromes involving craniofacial dysmorphia in 31%. Of the patients with syndromes, 56% had severe dentofacial disharmony (DFD), 22% moderate and 22% mild; with LRF/PV, 44% had mild DFD, 56% had no DFD; with SAO, 36% had moderate DFD, 18% mild DFD and 45% had no DFD. The results indicate a high incidence of abnormal dental harmony, varying in degree, among tracheostomized children at an early age.

Keywords: Pediatric tracheostomy, dentofacial disharmony, absence of nasal flow

Introduction

Most newborns have a normal craniofacial morphology, standard maxillomandibular relationship, and the potential for a functional airway. In these newborns, the alveolar process accommodates the tongue and future teeth with ease.[1]

However, some children may have multiple dentofacial abnormalities, such as poor maxillomandibular relationship, accentuated mandibular angle, anterior open bite, high-arched palate, posterior crossbite, and compromised facial development.

Facial development is influenced by several oral factors, including breastfeeding, upper airway obstruction, mouth breathing, oral resting position, and oral habits. It is also affected by long-term myofunctional orofacial dysfunction that is associated with chronic untreated oral dysfunctions involving the lips, maxilla, tongue, and oropharynx, which interfere with the growth, development, and function of other oral structures.[1]

Breastfeeding is often considered the first and perhaps the most crucial factor for facial development. Unlike bottle feeding, breastfeeding requires infants to pull the breast into their mouth, and involves repeated pressure and peristaltic movements that expand the breast and shape the hard palate.[1,2] Additionally, breastfeeding requires maxillary compression, which optimizes the development of the masseter muscles and leads to improved facial development compared to bottle-fed children.[3]

Exclusively breastfed children have a lower incidence of malocclusion, decreased rates of anterior[4] and posterior open bite, increased overjet,[5,6] and greater intercanine and intermolar width.[7]

Very young children typically breathe quietly with their lips closed. However, some factors can disrupt this process and affect craniofacial growth.[1] Allergic rhinitis has been correlated with both anterior and posterior open bites,[8] while adenoid facies is commonly observed in patients with adenotonsillar hypertrophy, retrognathia, accentuated mandibular angle, and increased anterior height of the lower third of the face.[9] Prolonged mouth breathing causes the mandible to rotate posteriorly and inferiorly, altering its morphology and increasing the anterior height of the lower third of the face. The tongue's position drops, and the maxilla loses the counterbalancing effect of the tongue muscles, as the position of the tongue against the palate promotes anterior and lateral maxillary growth and development of facial muscles. Maxillary development can only adequately support mandibular growth if associated with a nasal breathing pattern with closed lips. Conversely, oral breathing disrupts this process, leading to a vertical growth pattern and preventing harmonious mandibular growth relative to the maxilla. Insufficient space in the maxilla and mandible to accommodate teeth in turn leads to misalignment.[14] Additionally, transverse maxillary reduction narrows the nasal cavities by reducing the nasal floor, exacerbating nasal breathing difficulties and creating a vicious cycle. Some studies have suggested that using palatal expanders in pediatric patients can reduce nasal resistance and improve nasal airflow.[16] Compared to children with normal breathing patterns, mouth breathers are more likely to develop posterior crossbites, anterior open bites, and high-arched palates.[11]

The ability to breathe effortlessly through the nose, with the tongue resting on the palate and the lips closed, is crucial for proper craniofacial growth.[12] Tongue-palate stability maintains the palatal arch while supporting the anterior middle and lower third of the face. Conversely, a low resting tongue position is strongly associated with malocclusion.[13]

Tracheotomy, as an alternative airway passage, bypasses the nasal cavities, nasopharynx, oropharynx, hypopharynx, and larynx, with the air entering directly through the trachea. In tracheotomized patients, the previously discussed mechanisms regarding the importance of nasal breathing for normal craniofacial development are disrupted. However, there is a lack of studies that describe the dentofacial changes in young pediatric patients undergoing tracheotomy.

Therefore, the objective of this study was to characterize the population of tracheotomized children being followed up at the Dona Estefânia Pediatric Hospital, São José Local Health Unit, and to describe the dentofacial changes observed in this group.

Materials and methods

This retrospective study analyzed the medical records of tracheotomized patients treated between 2009 and 2022 at the Dona Estefânia tertiary pediatric hospital, União Local de Saúde São José, Portugal. A total of 57 patient records were initially reviewed. The exclusion criteria were death, tracheotomy for less than a year, and tracheotomy performed on children seven years or older. After applying these criteria, a final sample of 29 patients (n = 29) was obtained. Frontal and profile photographs, along with intraoral dental images, were collected for each patient, and were subsequently examined by a stomatologist, with parental consent. Dentofacial disharmony (DFD) was classified as mild, moderate, severe, or absent,[18–20] following the classification outlined in Table 1.

Results

In the study population, the female-to-male ratio was 7:22. The average age at tracheotomy was three months (range: 0–77 months). Tracheotomy was indicated for upper airway obstruction or laryngeal obstruction in 38% of cases (11 patients), low respiratory failure or prolonged ventilation in 31% of cases (nine patients), and syndromes associated with craniofacial dysmorphism in 31% of cases (nine patients). The average period since tracheotomy was 65 months (range: 23–208 months). Among patients with velocardiofacial syndrome, Treacher Collins syndrome, Pierre Robin syndrome, Smith-Magenis syndrome, Goldenhar Syndrome, and other polymalformative genetic syndromes, 56% had severe DFD, 22% had moderate DFD, and 22% had mild DFD. Among the patients with low respiratory failure or prolonged ventilation, 44% had mild DFD and 56% had no DFD. Among those with upper airway or laryngeal obstruction, 36% had moderate DFD, 18% had mild DFD, and 45% had no DFD. The most frequent dentofacial changes identified in the cohort were high-arched

Table 1
Surgical-orthodontic classification of dentofacial disharmony [18-20]

This classification is widely used to assess the severity of DFD, based on a combination of clinical evaluation and cephalometric analysis. It includes the following categories:	
Mild disharmony	
Characteristics	Minor deviations in dental alignment or skeletal relationship
Clinical implication	The facial appearance is generally harmonious, with only slight dental misalignment or small maxillary discrepancies. Any functional issues, if present, are minimal
Therapeutic approach	Orthodontic treatment alone is usually sufficient to correct the disharmony
Moderate disharmony	
Characteristics	More noticeable discrepancies between the maxilla and mandible. Moderate tooth misalignment and possible functional problems, such as slight impact on speech or chewing
Clinical implication	Moderate effect on facial aesthetics and dental function. The maxillary relationship may exhibit discrepancies that interfere with occlusion
Therapeutic approach	A combination of orthodontic treatment and minor surgical procedures may be required to correct both the dental and skeletal components
Severe disharmony	
Characteristics	Significant misalignment of the maxilla and mandible. Severe dental crowding or spacing, along with major functional issues
Clinical implication	The facial profile is significantly affected, with a noticeable impact on facial aesthetics. There is a high potential for functional issues such as difficulty in chewing, speech problems, and temporomandibular joint (TMJ) dysfunction
Therapeutic approach	Comprehensive orthodontic treatment combined with orthognathic surgery is typically required to correct both the dental and skeletal components

palate (10 patients, 34%), anterior open bite (nine patients, 31%), increased overjet (eight patients, 28%), and posterior crossbite (six patients, 20%), as shown in Table 2. Follow-up included stomatology appointments (38%), maxillofacial surgery appointments (14%), and dental/maxillofacial interventions (17%), such as mandibular or maxillary distraction, orthodontic treatment, and dental care for caries management.

All patients underwent speech therapy aimed at valve or cap training for tracheotomy cannula occlusion, although not all patients tolerated this intervention.

Table 2
Tracheotomized patients by etiology, dentofacial change, and degree of DFD

Patient	Sex	Etiology	Dentofacial change	Degree of DFD
1	Male	Upper airway or laryngeal obstruction	No changes	0
2	Male	Upper airway or laryngeal obstruction	Anterior open bite, increased overjet, high-arched palate	Moderate
3	Male	Upper airway or laryngeal obstruction	Anterior open bite, increased overjet, high-arched palate	Moderate
4	Female	Upper airway or laryngeal obstruction	Anterior open bite	Mild
5	Male	Upper airway or laryngeal obstruction	No changes	0
6	Female	Upper airway or laryngeal obstruction	No changes	0
7	Male	Upper airway or laryngeal obstruction	Increased overjet, posterior crossbite, dental crowding, retrognathia	Moderate
8	Male	Upper airway or laryngeal obstruction	Posterior crossbite	Mild
9	Male	Upper airway or laryngeal obstruction	No changes	0
10	Male	Upper airway or laryngeal obstruction	No changes	0
11	Male	Upper airway or laryngeal obstruction	Increased overjet, posterior crossbite, retrognathia, mandibular asymmetry	Moderate
12	Male	Low respiratory failure or prolonged ventilation	Posterior crossbite	Mild
13	Female	Low respiratory failure or prolonged ventilation	No changes	0
14	Female	Low respiratory failure or prolonged ventilation	No changes	0
15	Male	Low respiratory failure or prolonged ventilation	Posterior crossbite	Mild
16	Male	Low respiratory failure or prolonged ventilation	Enamel dysplasia	0
17	Female	Low respiratory failure or prolonged ventilation	No changes	0
18	Male	Low respiratory failure or prolonged ventilation	Posterior crossbite, high-arched palate	Mild
19	Male	Low respiratory failure or prolonged ventilation	Anterior open bite, high-arched palate	Mild

20	Male	Low respiratory failure or prolonged ventilation	No changes	0
21	Female	Syndrome - craniofacial dysmorphia	Anterior open bite, demineralization of occlusal surfaces, calculus	Mild
22	Male	Syndrome - craniofacial dysmorphia	Anterior open bite, high-arched palate	Mild
23	Male	Syndrome - craniofacial dysmorphia	Dysmorphic teeth, increased overjet, high-arched palate, lower dental crowding	Severe
24	Female	Syndrome - craniofacial dysmorphia	Mandibular asymmetry, upper and lower dental crowding	Severe
25	Male	Syndrome - craniofacial dysmorphia	Anterior open bite, increased overjet, high-arched palate	Moderate
26	Male	Syndrome - craniofacial dysmorphia	Anterior open bite, limited mouth opening, severe micrognathia, increased overjet, high-arched palate, lower dental crowding	Severe
27	Male	Syndrome - craniofacial dysmorphia	Anterior open bite, high-arched palate, cavities	Moderate
28	Male	Syndrome - craniofacial dysmorphia	Microstomia, high-arched palate, severe cavities	Severe
29	Male	Syndrome - craniofacial dysmorphia	Micrognathia, dental agenesis, taurodontism	Severe

DFD, dentofacial disharmony

Discussion

Our analysis revealed shared characteristics across the study population. Vertical changes included reduced overbite with anterior open bite often associated with atypical swallowing, enlarged lower third of the face, high-arched palate, and occlusal plane modifications. Horizontal changes comprised an increased horizontal overjet with a retracted mandible (Angle's skeletal class II[21]), along with the presence of diastemas. All patients exhibited a dolichofacial biotype, characterized by weak musculature, elongated facial structure, and a convex profile. The dental changes observed in this population were remarkably similar to those described in patients with nasal obstruction or mouth breathing.[14] This similarity can be attributed to the fact that these patients do not require or cannot tolerate nasal breathing from an early age, as the tracheotomy bypasses nasal airflow. The lack of nasal airflow disrupts the mechanisms essential for normal dentofacial development, resulting in these typical characteristics.

Additionally, many of these patients were unable to breastfeed due to prolonged ventilation or incubation, upper airway or laryngeal obstruction, or facial dysmorphia. As 22 patients (76%) underwent tracheotomy at or before six months of age, which is a critical period for breastfeeding, this factor may be involved in the etiopathogenesis of the dentofacial changes observed in these patients, such as malocclusion and high-arched palate. The prevalence of DFD was lower in patients tracheotomized for lower respiratory failure or prolonged ventilation compared to those tracheotomized for upper airway obstruction or laryngeal obstruction. In the first group, 44% of patients had mild DFD, while 56% had no DFD. In contrast, in the second group, 36% had moderate DFD, 18% had mild DFD, and 45% had no DFD. Patients with upper airway obstruction or laryngeal obstruction often have difficulty in tolerating tracheotomy tube occlusion and nasal breathing therapy, including myofunctional exercises (such as those used for patients with obstructive sleep apnea-hypopnea syndrome)[15] that improve nasal breathing. Conversely, oral breathing in these patients increases xerostomia, reducing the protective

Figure 1
Laryngeal obstruction and moderate dentofacial disharmony (Patient no. 7 in Table 2).

Figure 2
Laryngeal obstruction and moderate dentofacial disharmony (Patient no. 2 in Table 2).

effect of saliva and increasing the incidence of cavities and periodontal disease.[17]

Tracheotomized patients represent a complex population, both psychologically and emotionally, often presenting with multiple pathologies, severe conditions, prolonged hospitalizations, and frequent healthcare visits. Consequently, dental issues are frequently overlooked, leading to delayed referrals to stomatology or maxillofacial surgery services. This was the case for most of our patients, who did not undergo early interventions to address dental or dentofacial abnormalities caused by the absence or significant reduction of nasal breathing. Considering that more than 90% of facial growth occurs before adolescence, early intervention is crucial, ideally starting at the age of four years. Dentofacial treatment for tracheotomized patients should focus on restoring the balance of facial growth and development that has been disrupted by the tracheotomy.

This study has several limitations, including the absence of a control group to compare the prevalence of DFD and a small sample size. These limitations may be addressed by developing a comprehensive database of tracheotomized pediatric patients under seven years of age from multiple Portuguese or European hospitals, as the total number of pediatric tracheotomized patients is substantially low.

Conclusion

Our results highlight the high incidence of DFD in children who underwent early tracheotomy. To optimize the planning of dental and dentofacial treatment, often undervalued in this population, and to support proper growth, we recommend establishing a multicenter database to better characterize tracheotomized children.

Conflict of Interests

The authors declare that they have no conflict of interest regarding this article.

Data Confidentiality

The authors declare that they followed the protocols of their work in publishing patient data.

Human and animal protection

The authors declare that the procedures followed are in accordance with the regulations established by the directors of the Commission for Clinical Research and Ethics and in accordance with the Declaration of Helsinki of the World Medical Association.

Privacy policy, informed consent and Ethics committee authorization

The authors declare that they have obtained signed consent from the participants and that they have local ethical approval to carry out this work.

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Scientific data availability

There are no publicly available datasets related to this work.

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