

Correlation of Hypertrophic Adenoids and Tonsils with Craniofacial Growth, Occlusion, and Breathing Habit in 4–12-year-old Children

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ABSTRACT

Aim and background: To evaluate and compare growth and development, breathing habit, and occlusion in children with and without hypertrophic adenoids and tonsils.

Materials and methods: This cross-sectional study was conducted on a total of 78 participants, aged 4–12 years, with 52 children with adenoid/tonsillar hypertrophy (group I) and 26 healthy children (group II). For each participant, a detailed history of respiratory obstruction or infection was recorded, followed by an orthodontic evaluation. A lateral cephalogram was taken for airway space and cephalometric analysis. Descriptive and inferential statistical tests were computed using SPSS software version 21.

Results: Children with hypertrophic adenoids and tonsils showed a higher incidence of repeated tonsillitis (73.07%) and otitis media (17.3%). On assessing breathing patterns, 88.4% had the mouth breathing habit and 11.5% had the oronasal breathing habit. However, the difference was not statistically significant ($p > 0.05$). On intergroup comparison, there was a statistically significant difference observed in cephalometric and orthodontic parameters. A higher frequency of lip incompetency, constricted maxillary arch, class II molar relationship, and the posterior crossbite was observed in children with adenotonsillar hypertrophy. Children in group I reported increased overjet (4.9 ± 2.0), increased mandibular plane angle (28.8 ± 3.1), and decreased posterior facial height (61.8 ± 6.1) with a dolichofacial profile ($p < 0.05$).

Conclusion: Adenoid or tonsillar hypertrophy in children results in altered skeletal growth patterns, showing a higher tendency of increase in anterior facial height, dolichofacial profile, change in breathing patterns, and malocclusion in children.

Clinical significance: Hypertrophic adenoids and tonsils are the most common cause of respiratory obstruction in children. Such cases, if diagnosed at an early stage, can be dealt with in a holistic approach to not only intervene but also prevent growth-related problems in children.

Keywords: Adenoids, Child, Craniofacial development, Hypertrophy, Malocclusion, Mouth breathing, Radiology, Tonsillitis.

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INTRODUCTION

For decades, the influence of breathing patterns on the stomatognathic system has been a highly debatable and contentious topic in orthodontics and otolaryngology.¹ While some authors consider genetic and environmental factors to play a crucial role in changing the normal pattern of craniofacial growth, the majority believe that airway obstruction alters the pattern of growth, with typical facial features and dentition.^{2,3} Alteration in the posture or functions of orofacial musculature leading to altered growth and development of the craniofacial complex is explained through functional matrix theory (1969).^{4–6} One such factor influencing dentofacial morphology is the alteration in nasorespiratory function. For accurate diagnosis and appropriate management of developing malocclusion, it is important to understand its etiopathogenesis.

Nasal breathing plays a crucial role in promoting the harmonious growth of the dentofacial complex. However, when there is blockage in the nasopharyngeal zone, it can lead to breathing obstruction, prompting children to adapt to oral breathing.⁷ Among various factors contributing to this obstruction, adenoid hypertrophy (AH) stands out as the most prevalent cause, with a worldwide prevalence of approximately 34.46%.⁸ This condition can be understood in the context of Scammon's theory,⁹ which suggests that adenoids, being lymphatic tissue, undergo physiological enlargement, reaching their maximum size (up to 200%) between the ages of 5 and 10 years,

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followed by a subsequent regression until adulthood.¹⁰ Children are particularly susceptible to allergic reactions and infections, which can result in pathologic inflammation of the tonsils and adenoids, exacerbating the issue further.

Mouth breathing due to airway obstruction results in postural alterations of soft tissues and facial muscles, which influences the growth of skeletal tissue and the development of the dentition. Mouth breathers tend to have a lower or anterior tongue position, so there is no internal muscular force acting on the maxillary arch

against the external forces by facial muscles. This consequently results in the alteration of transverse dimensions of the maxillary arch, hence giving a long, narrow face appearance. To facilitate the airway, the mandible shows posterior inferior rotation with an inclination to the cranial base and steeper gonial angle, resulting in increased lower anterior facial height. Oral breathing also alters the posture, morphology, and tonicity of phonoarticular organs.⁶ AH may further lead to several comorbid conditions, including sneezing, itching, snoring, possible obstructive sleep apnea syndrome (OSAS), and increased respiratory infections such as ear infections, sinusitis, tonsillitis, and allergic rhinitis.¹¹ To our knowledge, very few studies^{6,10,12} have been conducted that focus on the association between adenotonsillar hypertrophy and breathing patterns, occlusion, and craniofacial growth, especially in the Indian pediatric population. The objective of the study was to evaluate and compare growth and development, breathing habit, and occlusion in 4–12-year-old children with and without hypertrophic adenoids and tonsils.

MATERIALS AND METHODS

An observational cross-sectional study was conducted after necessary approval from the Institutional Ethics Committee (SVIEC/ON/DENT/BNPG18/D19068, dated: December 10, 2019) and was registered under Clinical Trial Registry—India (CTRI/2021/03/032334).

Sample Size Calculation

Sample size was calculated based on previous records of the total number of patients reporting in the department of ENT within the age-group of 4–12 years using SPSS Statistics 21 software (SPSS Inc., Chicago, Illinois, United States of America). The sample size using standard normal distribution (z) of 1.96 for a confidence level of 95%, sample proportion (p) of 0.5, and margin error (e) of 0.05% was calculated to be 52 participants. An additional 20% was added to the final sample size to compensate for potential refusals for radiographic examination, leading to a final sample size of 60 participants for group I (children with hypertrophic adenoids/tonsils). A purposive sampling method was followed to achieve the determined sample size. For group II (healthy children), the sample size was determined based on a ratio of 2:1, resulting in a final sample size of 26 participants (Flowchart 1).

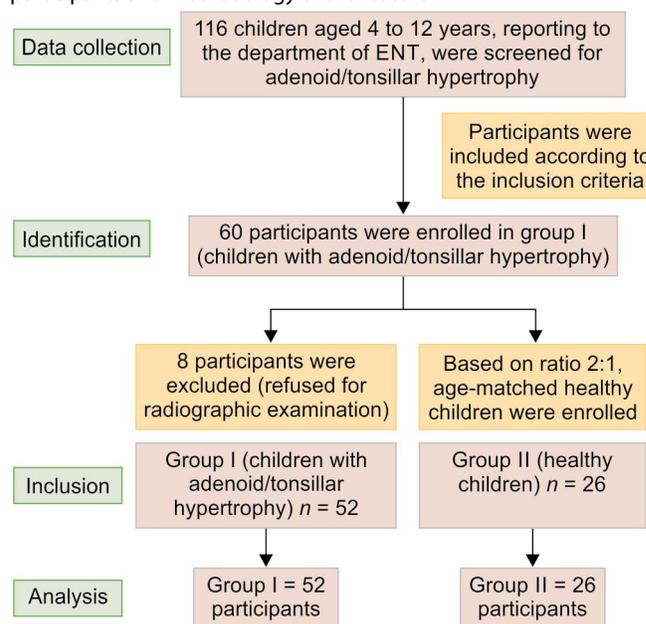
Selection Criteria

Participants and their parents were thoroughly informed about the study as well as the examinations that would be performed. Those who agreed and signed the informed consent were included in the study. Children with hypertrophy of adenoids (value <1.0) and/or tonsils (grade III and IV) with signs of respiratory obstruction were included in group I. Children without AH or palatine tonsils with no signs of respiratory obstruction and with normal nasal breathing habits were included in group II. Children with a history of maxillofacial trauma or surgery, cleft lip and cleft palate, with a history of adenoidectomy, deviated nasal septum, nasal polyps, or hypertrophic nasal turbinates, with any oral habits, and those undergoing orthodontic treatment were excluded from the study.

Selection of Participants for Group I

A total of 116 children between 4 and 12 years, reporting to the department of ENT, were screened by the principal investigator for adenoid/tonsillar hypertrophy. Among these, 60 children were enrolled based on the selection criteria, out of which 8 refused

Flowchart 1: Flowchart depicting methodology distribution of participants and methodology of the research



for radiographic examination, leading to a final sample size of 52 children.

Selection of Participants for Group II

After selection and enrolment of participants in group I, age-matched healthy children were selected based on the ratio of 2:1, leading to a sample size of 26 children. This group included healthy children with no signs of respiratory obstruction.

The principal investigator was trained and calibrated for clinical evaluation and cephalometric analysis. To achieve and determine reliability, lateral cephalograms of 10 pediatric patients were traced and analyzed repetitively. The intrareliability was then assessed by the test and retest method, wherein kappa analysis was equal to 0.92.

Method of Examination

After selection and allocation of the participants, demographic details were entered in the proforma. Parents were then interviewed for the child's history pertaining to respiratory obstruction or infection, such as incidence of otitis, sleep apnea, frequent tonsillitis, snoring, allergic rhinitis, and breathing pattern during sleeping, and it was recorded.

Orthodontic Evaluation

It was conducted based on photographic analysis as well as clinical examination. Both front and lateral profiles were captured to evaluate parameters such as facial profile, facial divergence, facial symmetry, and lip posture. For the evaluation of breathing habit, the fog test/mirror test was performed for each participant. On clinical examination, the parameters evaluated were overjet, overbite, crossbite, molar relationship, arch alignment, and shape of the arch.

Assessment of the Size of Tonsils

Physical examination of the tonsils was accomplished by placing two tongue depressors gently on the anterior two-thirds of the tongue in front of the circumvallate papillae to prevent gagging



Fig. 1: Clinical photograph of normal tonsils (group I)



Fig. 3: Lateral cephalogram of a child without AH (group I)



Fig. 2: Clinical photograph showing tonsillar hypertrophy in a child (group II)



Fig. 4: Lateral cephalogram of a child without AH (group II)

and medial displacement of the tonsils and was classified according to Brodsky's grading system¹³ (Figs 1 and 2).

Assessment of the Size of Adenoids and Growth of Dentofacial Complex

Radiographic examination was conducted to evaluate AH and growth of the dentofacial complex. For this, a lateral cephalogram was recorded in the department of oral medicine and radiology using Kodak 8000C digital panoramic and cephalometric system with a magnification of 1.14; exposure: 2–15 mAs, 60–90 KV, 0.1–3.2 seconds. Hypertrophy of adenoids was assessed by measuring airway-to-soft palate ratio on lateral cephalogram and was classified according to Cohen and Konak's method¹⁴ (Figs 3 and 4). For cephalometric analysis, the parameters evaluated were as follows:²

- Sagittal position of maxilla [Sella–Nasion–A point (SNA)] and mandible [Sella–Nasion–B point (SNB)].
- Sagittal jaw relationship [A point–Nasion–B point (ANB)].
- Mandibular plane angle [Frankfort–Mandibular plane angle (FMA)].
- Anterior facial height [Nasion–Menton (N-Me)].
- Total posterior facial height [Sella–Gonion (S-Go)].

- Inclination of maxillary and mandibular incisors.

Statistical Analysis

The collected data were entered in Microsoft Excel (2016) spreadsheet and analyzed using SPSS 23.0 software. Descriptive and inferential statistical analyzes were carried out in the present study. Chi-squared test, likelihood ratio (LR), and independent *t*-test were used for inter and intragroup comparison. Results were considered statistically significant at $p \leq 0.05$.

RESULTS

A total of 78 participants were included, divided into group I ($n = 52$, mean age: 9.53 ± 1.65 years) and group II ($n = 26$, mean age: 8.9 ± 1.5 years), with no significant age difference ($p > 0.05$). Among these 52 children with enlarged adenoids and tonsils, 45 (87%) were diagnosed with grade III tonsillar enlargement and 7 (13%) with grade IV according to Brodsky's grading scale. As per Cohen and Konak's evaluating criteria, 41 (79%) children reported mild-to-moderate, while 11 (21%) had severe AH.

On taking a medical history, 96.2% of the participants with hypertrophic adenoids and tonsils (group I) had a history of frequent upper respiratory tract infections. Among these, frequent tonsillitis was observed in a maximum of children, 38 (73.07%), followed by

otitis, 9 (17.3%), and rhinitis 3 (5.7%). Frequency distribution for the parameter, type of behavior while sleeping in children with hypertrophic adenoids and/or tonsils, it was observed that about 88% of the children had a habit of mouth breathing, followed by episodes of snoring (11.5%) and sleep apnea (9.6%).

Clinical assessment of breathing patterns in children with hypertrophic adenoids and tonsils revealed that 88.4% had mouth breathing habits and 11.5% had oronasal breathing habits. Normal nasal breathing was observed in children without adenotonsillar hypertrophy. Based on the LR of enlarged adenoids/tonsils to

a breathing pattern, it was indicated that there is an increased probability of altered breathing patterns in children with airway obstruction. However, the difference was not statistically significant ($p > 0.05$) (Table 1).

The orthodontic parameters of each participant with and without hypertrophic adenoids and tonsils are shown in Table 2. On intergroup comparison, there was a highly significant difference observed in assessing the shape of the arch, alignment, and transverse relationship ($p \leq 0.05$). About 53.8% of children in group I had a constricted (V-shape) maxillary arch with considerably higher

Table 1: Frequency distribution and intergroup comparison of type of breathing with and without adenotonsillar hypertrophy

<i>Breathing pattern</i>	<i>Group I (children with adenotonsillar hypertrophy) n (%)</i>	<i>Group II (healthy children) n (%)</i>	<i>p-value (Chi-squared test)</i>	<i>p-value (LR)</i>
Nasal breathing	0	26 (100)	0.3	0.2
Mouth breathing	46 (88.4)	0		
Oronasal breathing	6 (11.5)	0		

* p -value ≤ 0.05 : significant difference

Table 2: Frequency distribution and intergroup comparison with respect to orthodontic assessment in children with and without adenotonsillar hypertrophy

<i>Orthodontic evaluation</i>	<i>Group I (children with adenotonsillar hypertrophy) n (%)</i>	<i>Group II (healthy children) n (%)</i>	<i>p-value</i>	<i>p-value</i>
Facial profile				
Convex	52 (100)	20 (76.9)	NA ^a	NA ^a
Straight	0	6 (23.1)		
Facial divergence				
Anteriorly divergent	0	0	NA ^a	NA ^a
Posteriorly divergent	52 (100)	20 (76.9)		
Straight	0	6 (23.1)		
Lip posture				
Incompetent	38 (73.1)	0	0.2	0.09
Competent	7 (13.5)	26 (100)		
Potentially competent	7 (13.5)	0		
Shape of the maxillary arch			0.008**	0.002**
U-shape	24 (46.2)	26 (100)		
V-shape	28 (53.8)	0		
Shape of the mandibular arch				
U-shape	33 (63.5)	26 (100)	0.7	0.7
V-shape	19 (36.5)	0		
Alignment				
Spacing	7 (13.5)	0	0.06	0.02*
Aligned	20 (38.5)	26 (100)		
Crowding	25 (48.1)	0		
Posterior crossbite				
Absent	44 (84.6)	26 (100)	0.001**	0.004**
Present	8 (15.4)	0		
Molar relationship				
Class I	37 (71.1)	26 (100)	0.001**	0.001**
Class II	12 (23.1)	0		
End-on relationship	3 (5.7)	0		

^aNo statistics can be computed because one of the variables is constant; * p -value < 0.05 : significant difference; ** p -value ≤ 0.01 : highly significant difference

Table 3: Intergroup comparison based on cephalometric analysis of children with and without adenotonsillar hypertrophy

Cephalometric parameters	Group I (children with adenotonsillar hypertrophy) (n = 52)	Group II (healthy children) (n = 26)	p-value (t-test)
	Mean ± SD	Mean ± SD	
Overjet	4.5 ± 2.3	1.8 ± 0.63	0.001**
Overbite	3.1 ± 1.8	2.8 ± 1.3	0.46
SNA	78.25 ± 3.5	78.0 ± 3.8	0.81
SNB	73.9 ± 3.8	74.8 ± 3.4	0.31
ANB	4.0 ± 2.3	3.5 ± 1.0	0.24
FMA	28.9 ± 3.1	21.1 ± 3.5	0.001**
Cf-Go	48 ± 2.9	55.2 ± 3.8	0.001**
Total anterior facial height	100.5 ± 8.3	98.6 ± 5.5	0.27
Total posterior facial height	61.8 ± 6.1	65.5 ± 5.0	0.01**
Inclination of maxillary incisors	29.1 ± 8.1	19.9 ± 2.5	0.001**
Inclination of mandibular incisors	29.2 ± 7.6	23.9 ± 3.2	0.001**

*p-value < 0.05: significant difference, **p-value ≤ 0.01: highly significant difference

cases of crowding (48.1%) and incidence of posterior crossbite (15.4%) when compared to children in group II. On assessing Angle's molar relationship, participants with enlarged adenoids and tonsils showed substantially higher cases with class II (23.1%) and end-on (5.7%) molar relationship ($p \leq 0.05$). On determining the incisor relationship, children with adenotonsillar hypertrophy reported increased overjet (4.5 ± 2.3) as compared to children without adenotonsillar hypertrophy (1.8 ± 0.63). However, there was no statistically significant difference reported in overbite in either of the groups (3.1 ± 1.8 vs 2.8 ± 1.3).

Intergroup comparison based on cephalometric analysis of children with and without adenotonsillar hypertrophy is shown in Table 3. It was observed that children with hypertrophic adenoids and tonsils had greater mandibular plane angle (28.9 ± 3.10) and lower posterior facial height (61.8 ± 6.1), indicating vertical and clockwise growth of the mandible. It was also noted that children in group I had significantly proclined maxillary (29.1 ± 8.1) and mandibular incisors (29.2 ± 7.6). On intergroup comparison, a highly significant difference was observed between both the groups with respect to mandibular plane angle, posterior facial height, overjet, and inclination of maxillary and mandibular incisors ($p < 0.05$).

Additionally, intragroup comparison based on the severity of hypertrophic adenoids and tonsils indicated a positive correlation observed between overjet, overbite, ANB angle, mandibular plane angle, anterior facial height, and inclination of mandibular incisors. A negative correlation observed between the severity of airway obstruction and posterior facial height, SNA, and SNB angle.

DISCUSSION

Nasal respiratory function and its relationship to the growth and development of craniofacial structures have been a subject of interest and controversy for over 100 years. The standard breathing pattern is nasal, and oral breathing is presumed to be an adaptive behavior or a habit acquired after birth, adapting to changes in nasal pathways. Controversy persists regarding the effects (if any) of nasal respiratory obstruction on the development of the facial skeleton and dental occlusion.¹⁵ The current observational study was thus conducted on children between the age of 4 and 12 years to evaluate and compare craniofacial growth and development, occlusion, and breathing pattern in children with and without

hypertrophic adenoids and tonsils. The selection of participants in groups I and II was based on a ratio of 2:1 to avoid unnecessary radiation exposure to normal healthy children.

In the present study, the severity of airway obstruction and the size of the tonsils were assessed through the Cohen-Konak method and Brodsky's grading system, respectively, owing to their high reliability and accuracy.^{16,17} Adenoids and tonsils are part of the nasopharyngeal-associated lymphoid tissues, which play an important role in the upper respiratory mucosal immune system. The adenoid serves as a barrier against pathogens that enter the upper respiratory tract through the nasal cavity. Exposure to allergens or bacteria stimulates adenoids, resulting in the proliferation of lymphoid tissues and secretion of immunoglobulins, resulting in cytotoxic action. Multiple exposures of adenotonsillar tissues to antigens or allergens result in persistent inflammatory reactions, thereby resulting in AH. Moreover, the biofilm present on the adenoids eventually acts as a reservoir of pathogens in the upper respiratory tract, leading to various infections, namely otitis media, rhinitis, tonsillitis, and sleep-breathing disorders such as snoring and sleep apnea. In the current study, researchers observed that 96.2% of children diagnosed with adenotonsillar hypertrophy had a history of repeated upper respiratory tract infections, with a significantly higher incidence of repeated tonsillitis (73.1%) followed by snoring (11.5%). In accordance, the study by Valera et al.⁶ reported a higher frequency of repeated tonsillitis (65.9%), itchy nose (47.7%), and hypersalivation during sleep (43.2%) in children with chronic respiratory obstruction due to AH.

The most common cause of mouth breathing is nasal obstruction, specifically AH in the pediatric population. The results of the present study indicated a positive association between altered breathing patterns and incidence of adenotonsillar hypertrophy, wherein 88.5% of children in group I were mouth breathers and 11.5% exhibited oronasal breathing habits. The results were as per the study by Valera et al.,⁶ where 50% of the children with hypertrophic adenoids reported oral respiration and 50% with mixed respiration patterns.

Adenotonsillar hypertrophy leads to obstruction of the nasopharyngeal airway, in turn resulting in mouth breathing habits and a typical facial appearance referred to as "adenoid face" or "long face syndrome." Bresolin et al.¹⁸ reported narrower

maxillary intermolar width in children with mouth breathing habits, with a higher rate of posterior crossbite. A similar finding was observed in the present study, wherein 53.8% of the cases exhibited a V-shaped maxillary arch with a considerably higher incidence of posterior crossbite (15.2%) and class II molar relationship (23.07%). This observation was following that reported by Harari et al.,⁷ wherein a higher prevalence of posterior crossbite (49%) and class II molar relationship (73%) in mouth breathers was observed. A similar study by Nunes and Di Francesco¹⁹ reported a higher rate of Angle's classes II and III molar relationship in children with isolated tonsillar enlargement and a highly significant correlation between class II molar relationship (43.2%) and combined adenotonsillar enlargement. This aberrant growth of the craniofacial skeleton is attributed to an imbalance in the "neutral zone," resulting due to lowered tongue position and elongation of the buccinator muscle creating inward pressure on the maxillary arch.⁷ This can further lead to constriction of the upper arch with marked arch length discrepancy resulting in crowding, as observed in 48% of the cases in the present study.

On orthodontic evaluation, the current study reported that 73% of children in group I had lip incompetency compared to 0% in group II, noticing a statistically significant difference ($p \leq 0.05$). Furthermore, evaluation of the anteroposterior relationship revealed significantly greater overjet (4.5 ± 2.3) in children with adenotonsillar enlargement when compared to children without adenotonsillar enlargement (1.8 ± 0.63). On the contrary, Sidlauskiene et al.²⁰ found no significant difference in overjet in children with and without nasal obstruction. Also, in the current research, there was no significant association found between the vertical relationship (overbite, deep bite, or open bite) and nasopharyngeal obstruction. A similar finding was reported by Bresolin et al.,¹⁸ Nunes and Di Francesco,¹⁹ and Osiatuma et al.²¹

Concerning craniofacial growth and development, it was observed that children with hypertrophic adenoids/tonsils have a considerably greater mandibular plane angle (FMA = 28.9 ± 3.1 vs 21.1 ± 3.4), decreased posterior facial height (61.76 ± 6.12 vs 65.46 ± 5.02), indicating vertical growth pattern and dolichofacial profile. On evaluating the anteroposterior position of the maxilla and mandible to the cranial base, no significant difference was observed in children with and without hypertrophic adenoids/tonsils ($p \geq 0.05$). The results were per the study by Valera et al.⁶ and Harari et al.,⁷ wherein higher mandibular plane angle (SN-GoGn), decreased posterior facial height, and lower BaN.PtGn measurement was observed in the study group. On the contrary, Bresolin et al.¹⁸ reported retrognathic maxilla and mandible in children with mouth breathing habits. Also, there was a highly significant difference observed in terms of the inclination of maxillary incisors (29.1 ± 8.1 vs 19.9 ± 2.6) and mandibular incisors (29.2 ± 7.6 vs 23.9 ± 3.2) with $p \leq 0.001$.

CONCLUSION

Based on the results of the present research, it can be concluded that adenoid or tonsillar hypertrophy can result in altered growth, change in breathing pattern, and malocclusion. There was a significant correlation observed between adenotonsillar hypertrophy and the incidence of mouth breathing habits. Children with adenoid or tonsillar hypertrophy showed increased overjet, anterior facial height, and greater mandibular plane angle (FMA), indicating clockwise rotation of the mandible.

Limitations

- Further studies are needed on a larger sample size.
- Long-term studies are needed to assess the effect on children postadenoidectomy.

Clinical Significance

Hypertrophic adenoids and tonsils are the most common cause of respiratory obstruction in children, in turn resulting in narrowing of the nasopharynx that can further lead to abnormal breathing pattern in an individual. Also, it can lead to postural alterations of facial muscles and thus influences craniofacial growth. In such cases, if diagnosed at an early stage, it can be dealt with in a holistic approach to not only intervene but also prevent growth-related problems in children.

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