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The Impact of Functional Jaw Orthopedics on Sleep-Related Breathing and Sleep-Related Bruxism: Case Series Study

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Abstract

Sleep-related breathing disorders (SRBDs) in children can lead to obstructive sleep apnea (OSA) in adulthood and sleep-related bruxism (SRB). Neuro occlusal rehabilitation and functional jaw orthopedics (NOR-FJO) show promise in addressing SRBDs and SRB to prevent OSA progression. However, consistent evidence for managing these conditions in children is lacking, highlighting the need for early intervention to mitigate long-term complications. The present article explores NOR-FJO's effects in preventing SRBDs and their progression to OSA. We report two cases of brothers with SRBD and SRB and the case of their father with OSA. The brothers, who had overjet and overbite, were treated with NOR-FJO. The third patient had a similar history in childhood, without treatment, and developed OSA, subsequently treated with a mandibular advancement device (MAD). Timely intervention for SRBDs is essential in preventing long-term health complications, and understanding treatment strategies is crucial for early intervention.

Keywords
- ► obstructive sleep apnea
- ► sleep bruxism
- ► mouth rehabilitation
- ► orthopedics
- ► growth and development

Introduction

Sleep-related breathing disorders (SRBDs) in children are associated with serious health implications, including the potential development of obstructive sleep apnea (OSA) in adulthood, which can lead to cardiovascular disease and neuropsychological changes.[1,2] OSA, in addition to being underdiagnosed and undertreated, carries a substantial economic burden.[3] The prevalence of SRBDs in children, often associated with mouth breathing and sleep-related bruxism (SRB),[4,5] raises concern due to the limited and inconclusive treatment options available, highlighting a significant gap in addressing these disorders.[6]

Reports indicate a close relationship between SRBDs and SRB, suggesting potential similarities in anatomical factors and cortical control.[7] Early detection and intervention for SRBDs prevent the progression to OSA in adulthood.[8,9] In this context, neuro-occlusal rehabilitation and functional jaw orthopedics (NOR-FJO) emerge as promising interventions for maintaining the functional balance of the stomatognathic system.[10] Preliminary studies suggest that NOR-FJO may lead to significant improvements in functional stability, including the remission of snoring and the normalization of nasal breathing.[11,12]

Understanding the core concepts of craniofacial skeletal growth and development, as well as the impact of interventions on growth potential, is vital to the success of early intervention and growth redirection. This knowledge is essential for understanding the potential effects of FJO on the development of craniofacial structures in children and

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adolescents.[13,14] By elucidating the relationship between treatment strategies and growth dynamics, we can gain insights into how therapies such as NOR-FJO may influence both the immediate functional aspects and the long-term structural development of the orofacial complex, aiming to improve nasal breathing and prevent SRBD and SRB in children.

This case series aims to highlight the effects of NOR-FJO and its crucial role in preventing SRBDs, focusing on its ability to mitigate the progression of SRBDs and SRB into OSA in adulthood. By examining genetic and epigenetic factors, the current series emphasizes the importance of early intervention with NOR-FJO to reduce the long-term consequences of untreated SRBD.[15]

Case Description

The current study was conducted under the Case Reports (CARE) guidelines[16] and was approved by the appropriate ethics committee. Informed consent was obtained for all three cases involving two brothers and their father. The analysis was based on medical records from the first author's clinic, focusing on these three patients.

It is essential to highlight that diagnosing these disorders in children is a relatively recent practice. For over 30 years, the first author grounded their clinical practice in treating these disorders in children by addressing oral functions using NOR-FJO. At that time, clinical evaluations relied primarily on parental complaints and the patient's clinical history, as requesting examinations like sleep tests was not common practice. Although we now acknowledge the importance of polysomnography and specific questionnaires for achieving more accurate diagnoses in children,[17] in the case reports herein presented (1 and 2), the baseline diagnosis relied solely on clinical observations and parental complaints to identify sleep-related issues. The NOR-JFO clinical approach has always focused on promoting craniofacial growth and proper development with functional balance,[10] directing all interventions toward that goal.

Case 1

A 5-year-old boy presented with complaints from his parents about bruxism, snoring, respiratory allergies, and nocturnal mouth breathing. Clinical examination revealed class-II malocclusion, overbite, and overjet. Complementary radiographic examinations showed reduced upper airway space and underdevelopment of the lower facial region. The diagnosis indicated a lack of growth and development in the lower third of the face and restricted dynamic jaw movements. The treatment involved approximately eight years of intervention, including NOR-FJO, using functional jaw oral appliances (ICTP - Indirect Compose Tracks Planas, SN1 - Simões Network 1 with occlusal plan balance), and Planas direct tracks.

Case 2

A 9-year-old boy exhibited symptoms and clinical findings like those of his younger brother. He received a comparable

Table 1 Bimler cephalometric analysis of the basal, intermediate, and final treatment status of cases 1 and 2 neuro occlusal rehabilitation and functional jaw orthopedics.

Variables		Case 1						Case 2					
		5 years and 1 month – October 2003		9 years and 8 months – May/2008		12 years and 4 months – January 2011		9 years and 4 months – October 2003		11 years and 6 months – November 2005		13 years and 10 months – May 2008	
Factors		Value	Standard/Class.	Value	Standard/Class.	Value	Standard/Class.	Value	Standard/Class.	Value	Standard/Class.	Value	Standard/Class.
1	Upper profile ang. (N-A)	−1.07	Retrognathic	0.41	Orthognathic	0.93	Prognathic	1.75	Prognathic	2.69	Prognathic	5.22	Prognathic
2	Lower profile ang. (A-B)	19.97	Retrogenic	19.45	Retrogenic	14.81	Retrogenic	10.1	Retrogenic	10.14	Retrogenic	8.91	Orthogenic
3	Mandibular plane (Go-Me)	31.72	Leptognathic	31.07	Leptognathic	28.32	Mesognata	24.36	Mesognathic	25.24	Mesognathic	24.28	Mesognathic
4	Palatal plane (Ena-Enp)	−3.05	Retro-inclined	−0.51	Retro-inclined	−0.2	Ortho-inclination	−2.84	Retro-inclined	−1.90	Retro-inclined	−4.42	Retro-inclined
5	Clivus plane (Cls-Cli)	67.93	Mesobasal	69.64	Mesobasal	70.32	Leptobasal	66.71	Mesobasal	68.30	Mesobasal	68.08	Mesobasal
6	Stress axis (Cm-Me)		Post		Per		Post		Post		Post		Post
7	Cranial base (SN-FH)	11.51	Upward incline	11.96	Upward incline	12.86	Upward incline	11.63	Upward incline	12.43	Upward incline	12.36	Upward incline
8	Ascending ramus plane (C-Go Line)	2.92	Hyperflexion	−2.07	Hypoflexion	3.22	Hyperflexion	4.43	Hyperflexion	3.54	Hyperflexion	4.09	Hyperflexion
Linear measurements													
9	Upper jaw (A'-T)	48.5	Medium	51.92	Medium	54.43	Large	49.79	Medium	52.62	Large	56.22	Extremely large

(*Continued*)

Table 1 (*Continued*)

Variables		Case 1						Case 2					
		5 years and 1 month – October 2003		9 years and 8 months – May/2008		12 years and 4 months – January 2011		9 years and 4 months – October 2003		11 years and 6 months – November 2005		13 years and 10 months – May 2008	
Factors		Value	Standard/Class.	Value	Standard/Class.	Value	Standard/Class.	Value	Standard/Class.	Value	Standard/Class.	Value	Standard/Class.
10	TMJ position (T-Tm)	29.02	Medium	34.79	Large	34.3	Large	31.35	Medium	32.8	Large	35.22	Large
11	Overjet (A'-B')	15.21	Class II - Convex	14.99	Class II - Convex	12.61	Class II - Convex	7.26	Class I - Straight	7.94	Class I - Straight	7.11	Class I - Straight
12	Mand. projected length (B'-Tm)	62.3		71.72		76.12		73.88		77.47		84.33	
13	Facial depth (A'-Tm)	77.51	Medium	86.71	Large	88.73	Large	81.14	Medium	85.42	Large	91.44	Large
14	Anterior cranial base (N-S)	72.04	Medium	76.34	Long	76.73	Long	71.73	Medium	73.80	Medium	75.93	Long
15	Sella turcica height (S-FH)	18.22	Medium	18.50	Small	19.72	Medium	17.23	Small	16.01	Small	17.95	Small
16	Ascending ramus height (Co-Go)	46.43	Small	50.83	Medium	59.31	Medium	54.29	Medium	61.59	Large	61.36	Large
17	Nasion height (N-FH)	32.6	Large	32.32	Large	36.8	Large	31.7	Large	31.89	Large	34.21	Large
18	Total face height (N-M)	110.3	Small	123.96	Medium	134.31	Large	118.08	Medium	129.09	Large	136.14	Large
19	Alveolar height		Low		Low		Medium		Low		Low		Low
Angular analysis of skeletal profile													
20	Profile angle (1 + 2)	18.9	Convex	19.86	Convex	15.73	Convex	11.85	Convex	12.83	Convex	14.13	Convex
21	Suborbital facial height (FH-M)	77.66	Medium	91.64	Large	97.51	Large	86.38	Large	97.20	Large	101.94	Large
22	FH-M - A' TM		Medium-faced - Meso		Medium-faced -Meso		Long - faced - Lepto		Long-faced - Lepto		Long-faced - Lepto		Long-faced - Lepto
23	Sub facial index (A' TM-A' M)		Dolic		Lepto		Lepto		Meso		Lepto		Lepto
24	Upper basal angle (4 + 5)	64.88	Mesoprosopic	69.13	Mesoprosopic	70.12	Leptoprosopic	63.87	Mesoprosopic	66.40	Mesoprosopic	63.66	Mesoprosopic
25	Lower basal angle (3–4)	34.77	Leptobasal	31.58	Leptobasal	28.53	Mesobasal	27.2	Mesobasal	27.14	Mesobasal	28.71	Mesobasal
26	Total basal angle	99.65	Mesoprosopic	100.71	Leptoprosopic	98.64	Mesoprosopic	91.07	Mesoprosopic	93.54	Mesoprosopic	92.36	Mesoprosopic
Skeletal-dental analysis													
27	Upper incisor angle	84.38	Superior retrusion	103.23	Superior retrusion	106.82	Superior retrusion	113.71	Medium	114.04	Medium	113.1	Medium
28	Interincisor angle	160.6	Bi-retrusion	131.23	Medium	125.3	Medium	121.28	Medium	122.73	Medium	128.09	Medium
29	Lower incisor angle	115	Medium	125.54	Inferior protrusion	127.88	Inferior protrusion	125.01	Inferior protrusion	123.23	Inferior protrusion	118.81	Medium
30	Gonial angle	124.6	Leprognathic	119.00	Mesognathic	121.54	Leptognathic	118.78	Mesognathic	118.78	Mesognathic	118.37	Mesognathic
31	Mandibular diagonal (Gn-Co)	98.89	Small	111.99	Medium	121.8	Large	109.75	Medium	120.91	Large	126.27	Large

Abbreviations: The Bimler Cephalometric landmarks: S: Sella; N: Nasion; A: Point A; B: Point B; Go: Gonion; Me: Menton; Gn, Gnathion; ANS: Anterior Nasal Spine; PNS: Posterior Nasal Spine; Cls: Superior Clivus; Cii: Inferior Clivus; FH: Frankfurt Horizontal Plane; C: Capitulare; T: Vertical line in FH; Tm: Projection of the TMJ (Temporomandibular Joint); A': Projection of Point A onto the FH plane; B': Projection of Point B on the FH plane; Cm, Masticatory Center.

diagnosis and underwent an eight-year therapeutic regimen involving the same NOR-FJO therapy approach.

►**Table 1** shows the data of the Bimler Cephalometric Analysis of the basal, intermediate, and final status of cases 1 and 2 with the NOR-FJO treatment. We observed growth and development of the facial profile in both the upper and lower jaws, with greater magnitude in the lower third, as indicated by the anterior, vertical, and diagonal mandibular projection. The NOR-FJO intervention proved effective, addressing skeletal and dental disharmonies and improving function and esthetics for both children.

The Bimler Cephalometric Analysis follow-up from this period reveals a significant evolution of skeletal and dental parameters throughout the treatment.

Case 1

1. **Profile angles**: The total basal angle remained within the mesoprosopic classification (99.65–98.64), indicating stability in facial proportion. The upper profile angle (N–A) increased from −1.07 to 0.93, suggesting a trend toward prognathism. The lower profile angle (A–B) was maintained from 19.97 to 19.45 (retrognathic) but reduced to 14.81 at follow-up, indicating an improvement in mandibular position.
2. **Linear measurements**: The upper jaw increased from 48.50 (medium) to 54.43 mm (large), reflecting significant growth. Facial depth (A'–Tm) also increased from 77.15 (medium) to 86.71 mm (large). The cephalometric analysis showed changes in the ascending ramus height (Co-Go) from 46.43 to 59.31 mm and the mandibular diagonal (Gn-Co) from 98.89 to 121.8 mm over the treatment period.
3. **Skeletal-dental analysis**: The lower incisor angle showed a trend of lower protrusion, while the upper incisors showed a trend of lower retrusion and interincisal angles remained within the average, suggesting stable dental relationships.

Case 2

1. **Profile angles**: The total basal angle remained within the mesoprosopic classification, with values ranging from 91.07 to 92.36, indicating stability in facial proportion. The upper profile angle (N–A) increased from 1.75 to 5.22, suggesting a trend toward prognathism over time. The lower profile angle (A–B) improved from 10.1 (retrognathic) to 8.91 (orthognathic), indicating a correction in mandibular position relative to the upper profile.
2. **Linear measurements**: The upper jaw (A'–T) increased from 49.79 (medium) to 56.22 mm (extremely large), and the facial depth (A'–TM) also increased from 81.14 (medium) to 91.44 mm (large), reflecting significant vertical and horizontal mandible growth. Initially, the intervention addressed signs of underdevelopment in the total face height (N-FH), which increased from 118.08 to 136.14 mm. Additionally, the mandibular diagonal (Gn-Co) improved from 109.75 (medium) to 126.27 mm (large).
3. **Skeletal-dental analysis**: The lower incisor angle was corrected from 125.01 to 118.81, while the upper incisors and interincisal angles remained within average, suggesting stable dental relationships.

Significant improvements were observed in the adolescents following 8 years of NOR-FJO treatment, with sustained benefits documented over a follow-up period exceeding 10 years of posttreatment. These improvements included parental observation of their children's health, enhanced dental occlusion, increased posterior air space, normalized nasal breathing, and the cessation of snoring and bruxism, contributing to overall morpho-functional stability (►**Fig. 1A,B**). In addition, ►**Table 2** presents the type-4 sleep test showing the normality of the oxygen desaturation index.

Case 3

The 47-year-old father of the two brothers reported symptoms of snoring, severe OSA, alcohol consumption, and panic syndrome. After declining continuous positive airway pressure (CPAP) treatment, he was advised to use a mandibular advancement device (MAD), with a treatment duration of three years. (►**Fig. 2**)

Furthermore, case 3 exhibited anatomical characteristics similar to those of his children (►**Fig. 1A,B**), and after 3 years of using the MAD, the patient experienced improved sleep quality (►**Table 3**).

However, despite the initial positive outcomes, the patient chose to discontinue OSA therapy follow-up in favor of orthodontic treatment with another professional and subsequently underwent septal surgery. Tragically, the patient passed away at the age of 52 in 2013 due to a hemorrhagic stroke.

Discussion

The present case series explores the potential role of NOR-FJO in maintaining the functional balance of the stomatognathic system and its impact on the growth and development of craniofacial structures in children and adolescents. The association between untreated SRBDs in childhood and the development of OSA in adulthood with associated risks of cardiovascular disease and neuropsychological changes was the central focus of this study. The close relationship between mouth breathing and bruxism in sleep disorders underscores the importance of early diagnosis and treatment using minimally invasive techniques for the stomatognathic system.

The case of the father, who experienced OSA and associated comorbidities, illustrates the potential consequences of untreated SRBDs in childhood. The anatomical characteristics observed in the father, including class-II dental occlusion with deep bite and overjet, and restricted upper airway space, were also present in the children who received early NOR-FJO treatment. These findings suggest that early intervention with NOR-FJO may play an important role in preventing the progression of SRBDs to OSA in adulthood.

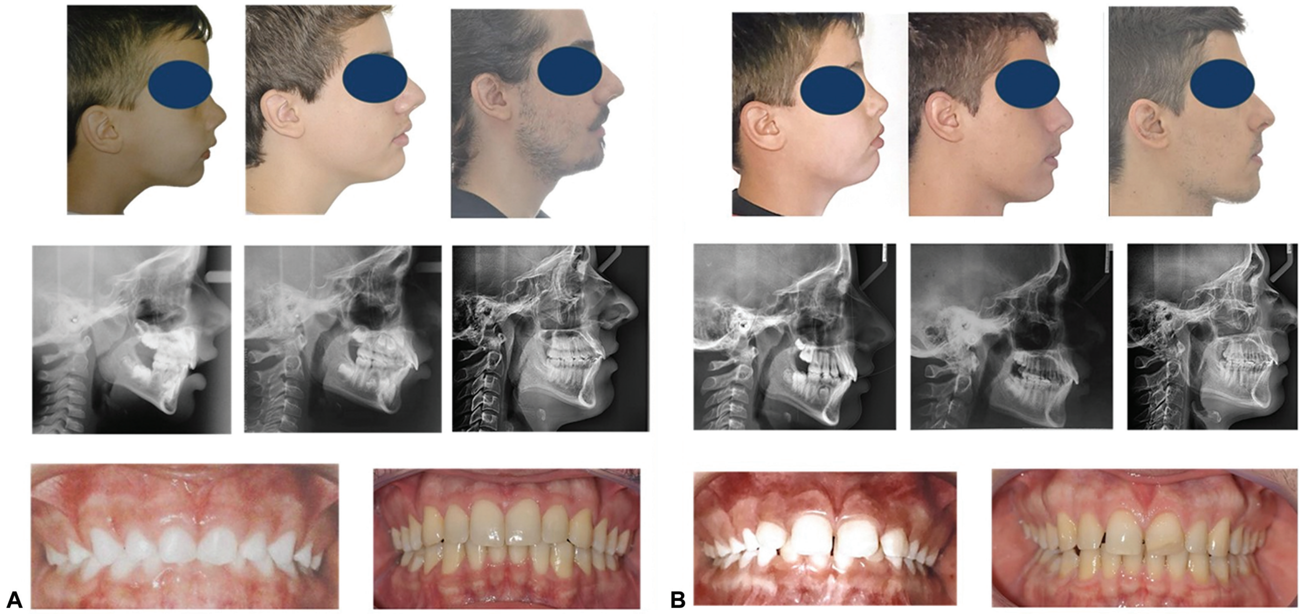

Fig. 1 (**A**) Case 1 shows the baseline facial profile during treatment and the follow-up of photography and teleradiographs. (**B**) Case 2 shows the facial profile baseline during treatment and following up with photography and teleradiographs.

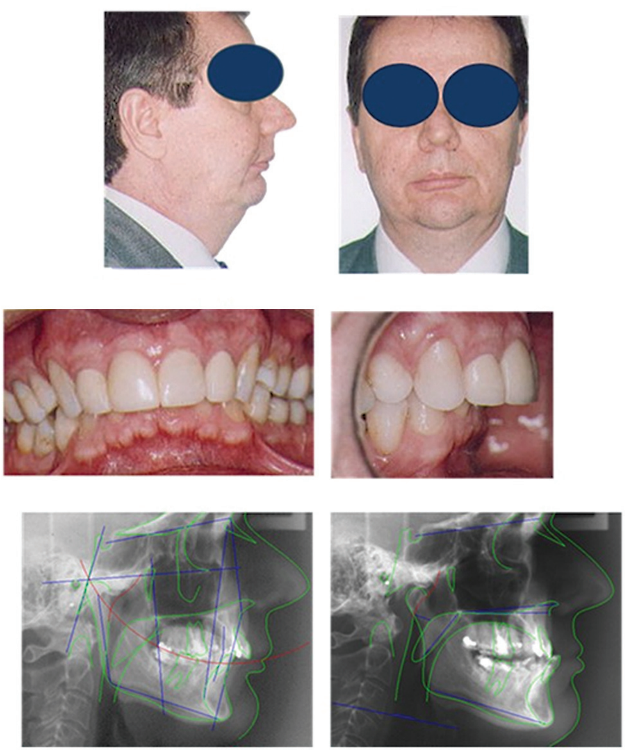

Fig. 2 Case 3 shows the facial profile baseline from photography and two teleradiographs, one in occlusion and the other in protrusion simulation, to observe the airway space.

Despite the promising results observed in the cases analyzed, it is important to acknowledge the limitations of this study. The evidence presented is limited to three cases, which restricts the generalizability of the results. Additionally, long-term follow-up is necessary to validate the sustained efficacy of NOR-FJO. The father's decision to discontinue OSA therapy follow-up, opting instead for orthodontic treatment and septal surgery, followed by a tragic outcome, highlights the importance of continuous and careful management of patients with OSA.

Table 2 Type-IV sleep test of cases 1 and 2.

Variables	Type-IV sleep test	
	Case 1	Case 2
Age, year and month	24 years	29 years and 3 months
BMI, Kg/m^2	22.4	19.9
TST, minutes	428.4	551.1
SpO2 minimum, %	90	91
SpO2 medium, %	94	95
ODI, events/hour	3.4	3.3
HR medium, bpm	58	56

Abbreviations: BMI, body mass index; TST, total sleep time; SpO2, oxygen saturation; ev./h, events per hour; ODI, oxygen desaturation index; HR, heart rate; bpm, beats per minute.

The present study reinforces the potential effectiveness of NOR-FJO intervention in restoring oral functions, supporting the proper development of the structures involved, and maintaining the functional balance needed to address SRBDs. However, due to the limited and inconclusive nature of the treatment options currently available, further research and development of effective interventions for SRBDs are necessary. Guilleminault's work[8] and other existing literature indicate that early intervention can prevent the development of OSA, and our study highlights the significance of NOR-FJO in growth dynamics and its potential to influence not only immediate functional aspects but

Table 3 Type-I polysomnography test baseline and with MAD case 3.

Variables	Case 3 - Type-I PSG test		
	Baseline	MAD	
Date	June 2008	November 2009	June 2011
Age	47 years and 3 months	48 years and 8 months	50 years and 3 months
BMI, Kg/m^2	26.6	26	26
SL, minutes	562.8	80	42.9
AI, events/hour	61.2	12.9	37.65
SE, events/hour	78.29	73.5	85.06
TST, minutes	374.5	301.5	366.5
TST REM, %	7.1	15.8	21.1
AHI, events/hour	48.87	19.9	12.77
SpO2 nadir, %	84	91	90

Abbreviations: AHI, apnea-hypopnea index; AI, arousal index; BMI, body mass index; ev/h, events per hour; MAD, mandibular advancement device; PSG, polysomnography; REM, rapid eye movement; SE, sleep efficiency; SL, sleep latency; SpO2, oxygen saturation; TST, total sleep time.

also long-term structural development of the orofacial complex.

Conclusion

In conclusion, NOR-FJO intervention may significantly improve nasal breathing, prevent SRBDs from childhood to adulthood, and mitigate the risk of associated complications later in life. However, the effectiveness of these interventions must be corroborated by additional studies with larger samples and longer follow-up periods.

Patient Perspective

The patients reported positive perceptions of the treatments they received. They emphasized that, in addition to significantly improving facial aesthetics, the treatment played a crucial role in shaping their oral structure, providing better breathing conditions, and enhancing sleep quality. While the treatment was not the only possible intervention, the patients highlighted that it was extremely important in improving their initial conditions and bringing about positive changes in their lives.

One of the most valued aspects by the patients was the improvement in respiratory functions, which resulted in an enhanced quality of life, with fewer episodes of bruxism and nocturnal mouth breathing. These advancements contributed to an overall sense of wellbeing and significantly reduced symptoms associated with SRBDs.

The patients also noted that the treatment improved their physical health and positively impacted on their confidence and satisfaction with their facial appearance. The personalized treatment approach was recognized as a key factor in the positive outcomes, with the patient's expressing gratitude for the opportunity to avoid potential complications arising from untreated SRBDs.

Ethics Statement

We declare that the patients and family approved the study by signing informed consent forms.

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Conflict of Interests

The authors have no conflict of interest to declare.

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