Review Article

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Sleep-related Breathing Disorder and Its Relationship with Temporomandibular Disorders: Literature Review

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In order to establish a relationship between sleep related breathing disorder (SBD) and temporomandibular disorders (TMDs), a literature review was performed. A researching was performed based on PubMed, including english languages. Any clinical study identified relationship between SBD and TMD were selected in this review. 13 studies were analyzed in this review. According to SBD diagnosis, articles were grouped as follows: polysomnographic diagnosis (n=7), clinical diagnosis (n=2) and survey/self-report (n=4). 12 articles established a positive relation between SBD and TMD and 1 did not. SBD would be associated with protrusion/retrusion degree, myofascial pain, muscular and joint pathology, and other orofacial findings. It was analyzed that the retrusion of the mandible had the significant influence on the severity of the SBD.

Key Words: Sleep related breathing disorder, Temporomandibular disorders, Relationship, Retrusion of mandible

INTRODUCTION

Sleep disorder refers to the medical abnormality in sleep patterns, and in severe cases, it interferer with daily life and social activities. International Classification of Sleep Disorders-3 (ICSD-3), revised in 2014, classifies sleep disorders into insomnia, sleep-related breathing disorder, central disorder of hypersomnolence, circadian rhythm sleep disorder, parasomnia, sleep-related movement disorder.[1)] Sleep related breathing disorder is characterized by pauses in breathing or periods of shallow breathing during sleep. In the common form, this follows loud snoring. Because it disturbs normal sleep, it is classified as a part of sleep disorders. In a domestic study, sleep apnea has an average of 3～4.5% prevalence in adults.[2)]

American Academy of Orofacial Pain (AAOP) defines temporomandibular disorders (TMDs) as 'a group of disorders including the masticatory muscles, the temporomandibular joint(TMJ), and related structures'.[3)] In 2014, National Institute of Dental and Craniofacial (NIDCR) reported a prevalence of TMDs is 5～12%. In 2009, Yang investigated a prevalence of TMDs patients visited hospitals and identified it gradually increased over 3 years since 2003.[4)]

Based on the evidence, the association between sleep-related breathing disorder and TMD is still controversial in the literature due to the complexity of the etiology and diagnostic of both disorders. Although there are some studies show a positive relation between sleep-related breathing disorder and TMD. the relationship of both disorders is still indistinct. The Review studies about the relationship between sleep apnea and TMD published in 1999,[5)] 1996[6)] and the relationship only about children in 2013.[7)] There has been no study about relationship between sleep-related breathing disorder and TMD targeting all ages since the 21st century. The aim of this study is to find out whether sleep-related breathing disorder is related with TMDs.

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MATERIALS AND METHODS

To establish the relationship between TMD and sleep-related breathing disorder (SBD), a literature review was conducted without limitation of publishing dates. PubMed was used as the database.

1. Types of studies

Analytical case-control, cohort, cross-sectional studies who have clearly defined aims to determine the relationship between SBD and TMD.

2. Language studies

The search was conducted with English literature.

3. Types of participants

The studies selected for this review included subjects without limitation of age, gender, race.

4. Intervention type

Studies without intervention in order to identify relationship between TMD and SBD.

5. Types of results

Primary outcomes: to determine the relationship between SBD and TMD.

Secondary outcomes: to determine the relationship between SBD and TMD by pathology.

6. Data collection

For TMD: Data were collected from studies showed diagnosis of TMD not limited to any method (ex. diagnostic criteria of TMD (DC/TMD), Radiography).

For SBD: Data were collected from studies showed a diagnosis of SBD. The included diagnostic studies were as: (1) polysomnography diagnosis (PSG); (2) clinical diagnosis with or without self-report and (3) self-report and/or questionnaire.

For the identification and selection of the number of potentially eligible studies for this review (N), a semantic field was determined for the term "SBD" ('apnea', 'snoring', 'breath') and another semantic field related to the term "TMD" ('temporomandibular', 'craniomandibular', 'TMJ', 'orofacial', 'TMD', 'disc displacement') using PubMed database (Table 1).

Table 1. Search Strategy and Terms Used for the Search

Database and limits	Search strategy and terms
PubMed (N=189) Languages: English	(apnea [tiab] OR snoring [tiab] OR breath [tiab]) AND (temporomandibular [tiab] OR craniomandibular [tiab] OR TMJ [tiab] OR orofacial [tiab] OR TMD [tiab] OR "disc displacement" [tiab])

7. Study selection and data collection

For study selection, studies were firstly selected by title and abstract. The articles selected were read fully. During analysis of articles, three questions of elimination based on the inclusion criteria were considered for selection of studies: (1) Is it a clinical study? (2) Does study not involve interventions? (3) Is the relationship between SBD and TMD established? Articles met these criteria were included in the review for the final analysis. The reason why some studies were excluded were recorded in 'Table 2'. The excluded or other related studies were used at Discussion to supplement explication.

8. Extracting data from the studies

The PICO criteria (population, intervention, control groups, outcome) were used to establish tables of analysed studies: population (sample size, distribution of subjects by gender and age range), intervention (main variables to compare, related to the topic, statistical analysis and confidence interval, type of method used for the diagnosis of SBD and TMD), comparison criteria or control (presence of any con-

Table 2. Studies Retrived in Full Text and Excluded from the Review

Author and year	Reason of exclusion
Harrell WE Jr, 2017[8]	Case report without comparison group, showing no association
Long J, 2017[9]	Evaluates only bite opening and mandibular protrusion, not temporomandibular disease (undiagnosis)
Olmos SR, 2016[10]	It was not in the inclusion criteria (It is not clinical study)
Hao Z, 2016[11]	It was not possible to obtain this article
Bakke M, 2014[12]	It was not associated with sleep-related breathing disorders
Spencer J, 2013[13]	It was not in the inclusion criteria (It is not clinical study)
Lam DJ, 2010[14]	It was not associated with temporomandibular disease (about congenital craniofacial anomalies; orofacial cleft, Down syndrome)
Will MJ, 1995[15]	It was not possible to obtain this article
Reimão R, 1994[16]	Case report without comparison group, showing no association
Sugahara T, 1994[17]	Case report without comparison group, showing no association

trol group) outcome (answer to the hypothesis, presence of relationship between SBD and TMD).

RESULTS

189 potentially eligible studies were searched in the PubMed database (Table 1). Based on the selection by title and abstract, 23 articles were selected. Of the 23 articles 10 were eliminated in the reading of full text due to not meeting the inclusion criteria for this review (Table 2). Finally, 13 studies were analysed (Fig. 1).

1. Included studies

In all, 13 studies were analyzed in this review. The analysis tables were established according to the PICO criteria (Tables 3-5). The studies analyzed were summarized in: (1) SBD diagnosed by polysomnography (PSG) (n=7); (2) SBD diagnosed clinically (n=2) and (3) SBD diagnosed by questionnaire and/or self-report (n=4).

2. Characteristics of participants

In relation to age, 4 studies included only children or adolescent.[18,25,26,28] 5 studies did not specify the both age and gender of participants.[19,20,22,24,30]

3. Categories of pathology of TMD

Among the analyzed articles, studies of TMD about muscular problem were 2,[18,27] joint problem were 4,[23,24,26,27] myofascial pain were 2.[21,22] The number of studies treated the other orofacial findings were 5.[20,24-26,28] About rheumatoid arthritis (RA) were 2.[19,23] Uncertain pathology were 2.[29,30]

DISCUSSION

In this review, a high relation was shown between SBD and TMD.

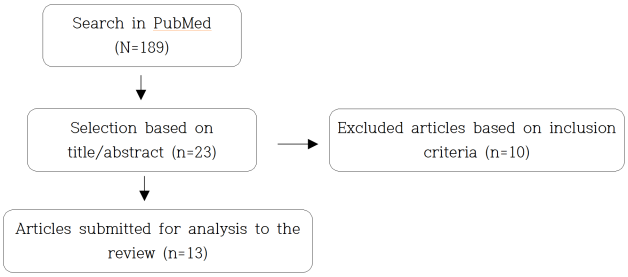

Fig. 1. Search method, identification, choice and inclusion of articles.

Majority of the included studies (n=7) based their SBD diagnostic on the PSG, and one-third of them based on the systematic questionnaire about sleep disorders. Because PSG includes the feature about breathing, it is valuable to analyze SBD. Besides, positive relations between SBD and TMD were founded in 12 from included 13 studies.

In this review, there was a variety of age range and gender, it does not explain about risk or association.

But there were some tendencies about specific temporomandibular pathology. And there was one thing to think that the other orofacial findings except for masticatory muscle, joint, and disc of the temporomandibular area should be examined for assessment of TMD.

Although it is not enough to prove the causal relationship, 12 from 13 studies showed a positive relationship. And there was such finding that the position of the mandible is an important factor for the development of TMD.

1. Relationship between SBD and TMDs based on analysis of selected articles

12 of the 13 analyzed papers identified the TMD and SBD, among the 12 papers, 5 articles directly discussed about relation between retrusion of mandible and SBD, 2 article were about orofacial findings affecting indirectly for position of mandible. 2 papers about myofascial pain indicated that each SBD and TMD could cause each other to develop.

De Felício CM at al. concluded children with OSA had relevant impairments in orofacial functions and lesser muscular coordination than primary snoring and healthy children.[18] They used 'Orofacial myofunctional evaluation with scores (OMES)' and masseter electromyography to evaluate the abnormality of orofacial structure, and confirmed that the OSA occurred more frequently when there was a abnormality of the mandible movement or the malfunction of the masseter muscle. Mutoh T at el. concluded that rheumatoid arthritis (RA) invading TMJ causes joint degeneration or micrognathia through inhibiting growth of mandible, and severity of TMD could be related with severity of OSA.[19] Study of Folha GA et al. had a strength that used validated scale-based instrument (PSG) as against former studies.[20] They identified OMES-expanded's validity through confirming the significant difference between OSA patients and controls. It was found that the observations of orofacial structures were an important part of the assessment of sleep-related breathing disorders. Alamoudi OS confirmed TMJ due to RA could cause retrognathia, then the severity of retrognathia could be

Table 3. Summary of Studies about Sleep Related Breathing Disorder Diagnosis Based Polysomnography

Author and year	Type of study	Population	Intervention	Comparison	Outcome	Conclusions	Pathology (TMD)
de Felício CM, 2016[18]	Cases and control s study	39 children (mean age 8±1.2 years)	OMES, Surface electromyography. Measurements of maximal lip and tongue strength SBD: PSG. Clinical examination Mann-Whitney test p<.05	OMES of healthy children (mean age=9±1.6) (n=15) Primary snoring (n=12) OSA (n=27)	Lower scores in breathing and deglutition, more unbalanced masticatory muscle activities than primary snoring (p<.05) in OSA, The mobility of the stomatognathic components score was the most important to contribute for group status (57%, p<.0001) in the regression analysis.	Children with OSA had relevant impairments in orofacial functions and lesser muscular coordination than primary snoring and healthy children	Muscular
Mutoh T, 2016[19]	Cross sectional study	62 patients with established RA	Disease activity index for RA : disease activity score 28-C-reactive protein, simple disease activity index, disease activity index, HAQ-DI, Cervical disorders associated with RA: atlanto-dental interval TMD associated with RA: TMJA SBD: polysomnography(RDI) logistic regression analysis. p<.1 Mann–Whitney U test and Spearman rank-correlation coefficient	No control group	Of the 62 RA patients, 23 (37%) patients showed RDI ≥15. 13 (20.9%) patients showed moderate- to-severe SAS (RDI≥20). The stage of TMJA was significantly higher in the RDI≥20 group than in the RDI<20 group (p<.0001). In RA patients with moderate-to-severe SAS (RDI≥20) as a complication, HAQ-DI was significantly high (HAQ-DI≥2; p=0.0001), as compared to HAQ-DI in those with RDI<20. HAQ-DI was≥2 in all patients with RDI≥20.	RA is related with sleep apnea and the highest TMJA stage and a high value of HAQ-DI are important risk factors for moderate-to-severe SAS in RA patients	Rheumatoid arthritis
Folha GA, 2015[20]	Cases and control study	133 subjects with/without OSA	OSA : PSG, Epworth Sleepiness Scale, Stanford Snoring Scale, AHI. Orofacial myofunctional disorders: OMES-expanded Spearman's correlation coefficient, Mann–Whitney U-test, Split-half method. p<.05	OSA group (n=99) Control group (n=34)	Construct validity: In comparison with OSA and controls, validity of OMES-expanded was demonstrated by the significant differences observed between patients with OSA and controls for the score of each category and for the total score (p<.0001) Criterion validity: There was a statistically significant correlation between the total scores generated by OMES-expanded and by the OMES protocol (r=0.88, p<.001)	Validity of OMES-expanded was good, as was its reliability. The OMES-expanded is valid and reliable for evaluating orofacial myofunctional disorders of patients with obstructive sleep apnea	Orofacial findings
Dubrovsky B, 2014[21]	Cases and control study	170 subjects (all women)	TMD : RDC/TMD. Clinical examination. Characteristic pain intensity. OSA : PSG recorded on 2 consecutive nights. The onset and offset times of nocturnal PSG recordings were determined from each participant's habitual bedtime and uptime ANCOVA models, Fisher exact test. p<.05	TMD group (n=124) Control group (n=46)	In comparison to healthy controls, TMD cased evidenced a significant increase in stage N1 sleep (12.2%±7.6% vs. 9.2%±5.0%, p=.03) TMD cases also demonstrated significant elevations in arousals associated with all types of respiratory events (6.0/h±6.1 vs. 3.5/h±3.3 p=.02) and in RERAs (4.3/h±4.3 vs. 2.6/h±2.7, p=.02). Myofascial pain predicted a lower sleep efficiency (p=.01), more frequent awakenings (p=.04), and higher RERA index (p=.04) among TMD cases.	Myofascial pain in TMD is associated with mild elevation in sleep fragmentation and increased frequency of RERA events. Further research is required to evaluate the clinical significance of these findings	Myofascial pain

Table 3. Continued

Author and year	Type of study	Population	Intervention	Comparison	Outcome	Conclusions	Pathology (TMD)
Smith MT, 2009[22]	Cases and control study	53 patients meeting RDC/TMD	TMD : RDC/TMD. Clinical examination Sleep disorders: clinical examination. Questionnaires(Brief Pain Inventory, Beck Depression Inventory, Spielberger State –Trait Anxiety Inventories, Insomnia Severity Index, Pittsburgh Sleep Quality Index, Fatigue Severity Scale, Epworth Sleepiness Scale). Self-report. PSG Laboratory Pain Testing Procedures: Pressure Pain Threshold, Heat Pain Threshold t-tests or t-tests of Pearson correlation coefficient. $p<.05$	Sleep disorders group (n=43) Good sleeper (n=10)	Two or more sleep disorders were diagnosed in 43% of patients. Insomnia disorder (36%) and sleep apnea (28.4%) demonstrated the highest frequencies. PI (26%) comprised the largest subcategory of insomnia. PI was associated with reduced mechanical and thermal pain thresholds at all sites ($p<.05$). The respiratory disturbance index was associated with increased mechanical pain thresholds on the forearm ($p<.05$).	High rates of PI and sleep apnea highlight the need to refer TMD patients complaining of sleep disturbance for polysomnographic evaluation. The association of PI and hyperalgesia at a nonorofacial site suggests that PI may be linked with central sensitivity and could play an etiologic role in idiopathic pain disorders.	Myofascial pain
Alamoudi OS, 2006[23]	Cross sectional study	10 patients in 7 women and 3 men (mean age±SD: 50±20 years, mean body mass index: 24.2±5.7 kg/m^2) with acquired retrognathia secondary to RA.	Acquired retrognathia: Clinical examination. Anthropometric measurements including weight, height, and neck circumference, and blood pressures OSA : PSG. AHI	No control group	Three patients had severe OSA with AHI >60/hour, three had mild obstructive sleep hypopnea (AHI >10/hour), and four had AHI <10/hour.	SBD occurs quite frequently in non-obese patients with acquired retrognathia secondary to RA. The severity of SBD is related to the degree of retrognathia and the presence of daytime sleepiness.	Joint/RA
Li KK, 1999[24]	Comparative study	351 patients with obstructive sleep apnea syndrome	Age, sex, BMI, PSG (RDI, LSAT), and cephalometric analysis data Mann–Whitney U-test, $p<.05$	Asian patients (n=58) White patients (n=293)	The Asians were younger (44.1 +/- 9.8 vs. 47.5 +/- 11.6 y, p=.02), and the mean BMI (kg/m^2) was 26.6 +/- 3.7 in the Asians and 30.7 +/- 5.9 in the whites ($p<.001$). The mean RDI was similar (56.6 +/- 34.9 vs. 55.6 +/- 26.9, p=NS), but the mean LSAT was lower in the whites (77.7 +/- 9.9% vs. 70.0 +/- 15.6%, $p<.001$). Based on the cephalometric data, the Asians have maxillomandibular protrusion, narrower cranial base angle, larger posterior airway space, and more superiorly positioned hyoid bone compared with the whites.	Variability in the craniomandibular factors that contributed to obstructive sleep apnea syndrome in the two groups was observed.	Joint/ Orofacial findings

PSG: polysomnography; OSA: Obstructive sleep apnea; TMD: Temporomandibular disorders; RDC/TMD: research criteria for temporomandibular disorders; SBD: sleep related breathing disorders; RA: rheumatoid arthritis; OMES: Orofacial myofunctional evaluation with scores; HAQ-DI: Health Assessment Questionnaire Disability Index; TMJA: TMJ abnormality; RDI: respiratory disturbance index; RERAs: respiratory effort related arousals; PI: Primary insomnia; AHI: apnea and hypopnea index; LSAT: lowest oxygen saturation; BMI: body mass index.

Table 4. Summary of Studies with Clinical Diagnosis of Sleep Related Breathing Disorder

Author and year	Type of study	Population	Intervention	Comparison	Outcome	Conclusions	Pathology (TMD)
AlHammad NS, 2015[25]	Cases and control study	60 children (mean age: 4.3±1.57)	Orofacial findings: frontal view, facial profile, mandibular angle, tongue size, dental midline to facial midline, upper to lower dental midline, overjet, overbite, anterior open bite, cross bite, scissors bite, palatal vault, maxillary and mandibular arch crowding and spacing, molar and canine relationship SBD: clinical examination Chi-square, proportional t-test and independent t-test. $p \leq .05$	OSA patients (n=30) Healthy group (n=30)	OSA group had steeper mandibular angle, deeper palatal vault, and less spaced upper and lower arches. There was no statistically significant difference between the two examined groups regarding facial morphology, facial profile, midline, anterior openbite, tongue size, posterior crossbite, overjet or molar relationship	OSA subjects had deeper palatal vault, steeper mandibular plane angle and less spaced upper and lower arches compared to control	Orofacial findings
Huynh NT, 2011[26]	Cross sectional study	604 subjects under 18 years (mean±SD, 13.01±2.28 years; range, 7~17 years)	4-part questionnaire including medical and dental histories, bruxism and temporomandibular disorder habits, sleep and daytime behavior, and sleep duration and quality. The sleep and daytime behavior questionnaire. PSQI. General clinical facial evaluation Asymmetries of the dental midline to the facial midline related to oral function A visual clinical evaluation of skeletal variables Palatal vault shape Visual clinical evaluation of the dental component of the malocclusion Pearson chi-square test and the Fisher exact test. Pearson chi-square test and the Fisher exact test. $p < .05$	No control group	Sleep-disordered breathing symptoms in this pediatric cohort were primarily associated with adenotonsillar hypertrophy, morphologic features related to a long and narrow face (dolichofacial, high mandibular plane angle, narrow palate, and severe crowding in the maxilla and the mandible), allergies, frequent colds, and habitual mouth breathing	All health care providers can evaluate whether a pediatric patient has, or is at risk of developing, symptoms of sleep-disordered breathing by noting factors associated with it reported by parents or patients and performing a thorough clinical examination	Joint/Orofacial findings

Table 5. Summary of Studies about Sleep Related Breathing Disorder Diagnosis Based Questionnaire

Author and year	Type of study	Population	Intervention	Comparison (control)	Outcome	Conclusions	Pathology (TMD)
Sanders AE, 2013[27]	Cohort/Cases and control study	2604 subjects (aged 18 to 44)/1716 subjects (aged 18 to 44)	TMD: RDC/TMD OSA: PSQI (loud snoring, trouble staying awake, witnessed apnea) + hypertension information. "STOP questions" People were considered to have high likelihood of OSA if they reported a history of sleep apnea or ≥2 hallmarks of OSA Cox proportional hazard regression, binary/multivariate logistic regression	No control group/TMD (n=182) Controls (n=1534)	In the cohort, 248 individuals developed firstonset TMD during the median 2.8 year follow-up and high likelihood of OSA was associated with greater incidence of first-onset TMD (adjusted HR=1.73; 95% CL, 1.14, 2.62). In the case control study, high likelihood of OSA was associated with higher odds of chronic TMD (adjusted OR=3.63; 95% CL, 2.03, 6.52)	Both studies supported a significant association of OSA symptoms and TMD, with prospective cohort evidence finding that OSA symptoms preceded first-onset TMD	Muscluar and joint pain
Sauer C, 2012[28]	Cohort	4,318 children (5.5±0.21 years, male 49.94%, female 50.06%)	PSQ was completed at school entrance examination by parents Interdisciplinary examination (otolarnygology/orthodontics and orofacial orthopedics) to investigate components of included children PSG; children with jaw abnormalities and no ENT operation needed and with compliance of parents	No control group	Results were based on 4,271 subjects of whom 140 had a positive PSQ score >0.33. corresponding to a SRBD prevalence of 3.3%. The gender ratio was 4.15% (n=88) of the boys and 2.46% (n=52) of the girls showed signs of SRBD. Lack of concentration, hyperactivity, morning fatigue, mouth breathing, loud snoring, and breathing interruptions were indicators of SRBD. The SRBD children more frequently presented with jaw abnormalities The SRBD cohort showed a higher rate of orofacial dysfunctions Adenotonsillar hyperplasia should be regarded as a major cause of SRBD.	3.3% of these 5~6 year olds present a risk for SRBD according to the validated PSQ. The prevalence of occlusion and jaw abnormalities was higher in this SRBD cohort. Adenotonsillar hyperplasia should be regarded as a major cause of SRBD. Snoring is an indication for SRBD, as more than half of our OSA cohort demonstrated that symptom.	Orofacial findings
Hoffmann RG, 2011[29]	Cases and control study	1511 TMD-affected subjects and 57 of their non-affected friends (mean age: 41 years old)	Web-based questionnaire: demographic information, information on experiences with pain and other physical and psychological symptoms, opinions about factors that caused TMD, medical and dental histories related to treatments for TMD, medication use, comorbid conditions, and information on quality of life t-tests, chi square, Fisher exact tests, Mann-Whitney U tests. Conditional logistic regression	TMD - affected group (n=1511) non-affected friends (n=57) NHANES controls had a similar prevalence of comorbid conditions	Roughly 60% subjects reported recent pain of moderate-to-severe intensity with a 1/4 of them indicating interference or termination of work-related activities. A higher frequency of headaches, allergies, depression, fatigue, degenerative arthritis, fibromyalgia, autoimmune disorders, sleep apnea, and gastrointestinal complaints were prevalent among those affected with TMD. Many of the associated comorbid conditions were over 6 times more likely to occur after TMD was diagnosed.	More interdisciplinary research, and the development of outcome-based strategies are needed to more effectively diagnose, prevent, and treat these chronic, debilitating conditions	Uncertain

Table 5. Continued

Author and year	Type of study	Population	Intervention	Comparison (control)	Outcome	Conclusions	Pathology (TMD)
Collesano V, 2004[30]	Cases and control study	200 subjects	TMD : RDC/TMD SBD: Douglass Sleep Disorders Questionnaire; (OSA was considered as present if the total Douglass questionnaire score reached or exceeded the cut-off point of 32 for women and 36 for men.) Epworth Sleepiness Scale; (a total >10 considered to indicate the presence of EDS) Chi-squared test. $p<.05$	TMD group (n=100) Controls (n=100)	EDS was found in 19% of the patients and in 10% of the control subjects, and OSA in 6 of patients and in 4 of control subjects. No statistically significant association emerged between TMD and OSA. EDS was more frequent in patients with myofascial pain.	Although most TMD patients complain of poor sleep quality, the age and sex prevalence of OSA was lower than that of TMD, and EDS was found to be present in only a few cases.	Uncertain

PSQI: Pittsburgh sleep quality index; OSA: Obstructive sleep apnea; TMD: Temporomandibular disorders; RDC/TMD: research criteria for temporomandibular disorders; PSQ: Pediatric Sleep Questionnaire; SRBD: sleep related breathing disorders; NHANES: National Health and Nutrition Examination Survey; EDS: excessive daytime sleepiness.

related with the degree of SBD.[23] Li KK studied about differences in characteristics of white and Asian color OSA patients, they proved mandible position in asian tend to have more protrusions, and lowest oxygen saturation (LSAT) is lower in the white group. However many factors, such as obesity and other harmful orofacial structures made it difficult to determine which characteristics were likely to be attributed to the OSA.[24] Huynh NT et al. analyzed adenotonsillar hypertrophy, morphologic features related to a long and narrow face (high mandibular plane angle, narrow palate, and severe crowding in the maxilla and the mandible), allergies, frequent colds, and habitual mouth breathing were related with OSA in study of under 18 adolescent.[26]

Among four studies used questionnaire for the diagnosis of SBD, Collesano V et al. compared 100 TMD patients with 100 normal group, there was no statistically significant association emerged between TMD and OSA.[30]

2. Comparison with previous studies

Like previous studies,[5,6] we analyzed relationship between SBD and TMD. 12 among the 13 studies showed a link between SBD and TMD as shown in the current study.

However, previous studies analyzed single pathology of TMD, on the other hand, in this study, it was intended to combine the results of the study in no limitation of pathology and find out what factors regarding TMD are related to the occurrence of SBD.

As a result of analysis about mandible's protrusion/retrusion degree, myofascial pain, muscular coordination, other orofacial findings, 5 articles directly discussed about the relation between retrusion of mandible and SBD, 2 article were about orofacial findings affecting indirectly for the position of the mandible. So pathology, which is most closely related to the SBD, was referred to as the retrusion of the mandible.

3. Investigation of other studies

Genioglossus (GG) muscle activity is augmented to maintain upper airway patency.[31] During sleep GG muscle activity is suppressed greatly and it may lead to partial or complete upper airway collapse. Then it can induce SBD. There were studies how much GG muscle activity varies depending on bite opening and protrusion of mandible.[9,31] The result of the study was that without protrusion of mandible, GG muscle activity increased from bite opening 4 mm to 12 mm. And the strongest signal was found in 4 mm bite opening and maximum protrusion of mandible.

The other study used Apnea Hypopnea Index for evaluation OSA patients in the therapy with mandibular advancement devices showed that advancement amounts higher than 50% do not significantly influence the success rate.[32)]

Past reviews about relationship between SBD and TMD were founded.[5,6)] The articles suggested dentists' role would be important because some sleep disorders seemed to be related to TMJ, and more controlled studies were required.

CONCLUSION

Although many studies and reviews have been made, it is not enough to confirm the causal relationship between SBD and TMD.

In relation to the findings in this review, we could conclude the following;

(1) Sleep-related breathing disorders would be associated with myofascial pain, muscular and joint pathology, and other orofacial findings.

(2) It is analyzed that position of the mandible(retrusion) has the greatest impact on the severity of the SBD.

(3) The orofacial structures such as high mandibular plane angle, narrow palate, and severe crowding in the maxilla and the mandible can affect the position of the mandible or upper airway patency. So multidisciplinary approach is needed in examining TMD patients.

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