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Original Article

Cervical Joint Position Error and Its Association with Bruxism and Pain Severity in Orthodontic Patients

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ABSTRACT

Background: Cervical proprioception contributes to coordinated head-neck-jaw motor control, and impairment in cervical joint position sense may influence parafunctional jaw activity and pain. In orthodontic patients, occlusal changes and appliance-related neuromuscular adaptation may increase the relevance of cervical sensorimotor assessment. Objective: To determine the association of cervical joint position error with bruxism risk and pain severity among orthodontic patients. Methods: This cross-sectional observational study included 115 orthodontic patients recruited through convenience sampling from dental hospitals and clinics in Lahore, Pakistan. Cervical joint position error was assessed using a laser-based cervical joint position error test and categorized as positive when angular error exceeded 4.5°. Bruxism risk was measured using the Bruxism Evaluation Questionnaire, with scores >15 classified as high risk. Pain severity was assessed using the Visual Analogue Scale and categorized as mild, moderate, or severe. Data were analyzed using IBM SPSS version 27.0.1. Descriptive statistics and Pearson's chi-square tests were applied, with statistical significance set at $p < 0.05$. Results: Of 115 participants, 56 (48.7%) had positive cervical joint position error and 88 (76.5%) were classified as high risk for bruxism. A significant association was found between cervical joint position error and bruxism risk, $\chi^2(1) = 24.076$, $p < 0.001$, Cramer's V = 0.458. Among CJPE-positive participants, 54/56 (96.4%) were at high risk for bruxism compared with 34/59 (57.6%) of CJPE-negative participants. CJPE was also significantly associated with pain severity, $\chi^2(2) = 17.743$, $p < 0.001$, Cramer's V = 0.393. Moderate-to-severe pain was reported by 41/56 (73.2%) CJPE-positive participants compared with 21/59 (35.6%) CJPE-negative participants. Conclusion: Cervical joint position error was significantly associated with elevated bruxism risk and greater pain severity among orthodontic patients. These findings support the integration of cervical proprioceptive assessment into orthodontic evaluation and highlight the clinical relevance of the cranio-cervico-mandibular system in orthodontic care. Keywords: Cervical joint position error; cervical proprioception; bruxism; orofacial pain; orthodontic patients; sensorimotor control.

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INTRODUCTION

Cervical proprioception is a critical component of sensorimotor control because the cervical spine functions as a major afferent source for head orientation, postural stability, visual tracking, and coordinated head-neck movement. The deep cervical muscles contain a high density of muscle spindles and mechanoreceptive structures that continuously transmit information regarding joint position and

movement to the central nervous system. This sensory input is integrated with vestibular and visual information to maintain head stability and guide precise motor responses during daily functional activities. When cervical joint position sense is altered, the resulting proprioceptive error may disturb neuromuscular coordination, increase compensatory muscle activity, and contribute to pain-related motor adaptations. Such dysfunction has been reported in individuals with neck pain, cervicogenic headache, dizziness, and temporomandibular dysfunction, suggesting that cervical proprioception should not be viewed as an isolated spinal function but as part of a broader craniofacial sensorimotor system (1).

The cervical spine and masticatory apparatus are anatomically and functionally linked through the cranio-cervico-mandibular system. Cervical afferents interact with trigeminal sensory and motor pathways, while mandibular movements are accompanied by coordinated activity of cervical and jaw muscles. Evidence showing coherence between jaw and neck muscle activity during bruxism supports the view that parafunctional jaw activity may involve integrated neuromuscular behavior rather than isolated masticatory muscle overactivity (2). Similarly, altered cervical proprioception has been reported among patients with bruxism-related temporomandibular symptoms, indicating that impaired neck sensory feedback may be associated with craniofacial pain and jaw dysfunction (3). These findings provide a biologically plausible mechanism through which cervical joint position error may influence mandibular motor control, parafunctional clenching or grinding, and pain perception.

This relationship is particularly relevant in orthodontic patients because orthodontic intervention modifies occlusal contacts, dental alignment, bite dynamics, and oral proprioceptive feedback. Although orthodontic treatment primarily aims to correct malocclusion and improve dental alignment, the neuromuscular consequences of changing occlusion and appliance loading may influence jaw muscle behavior and cervical posture. Bruxism, defined as repetitive jaw-muscle activity involving clenching, grinding, or bracing of the mandible, may occur during sleep or wakefulness and is associated with tooth wear, masticatory muscle discomfort, temporomandibular symptoms, and orofacial pain. In orthodontic populations, bruxism may complicate treatment by increasing mechanical stress on appliances, altering force distribution, delaying treatment progress, and affecting post-treatment stability (4). Current evidence also suggests that occlusion, orthodontics, and temporomandibular disorders should be interpreted within a wider biopsychosocial and neuromuscular framework rather than through a purely dental model (5).

Despite growing interest in the cervical-mandibular relationship, limited evidence is available regarding cervical joint position error in orthodontic patients, particularly in relation to bruxism risk and pain severity. Most previous work has focused on temporomandibular disorders, sleep bruxism, or general neck pain populations, leaving a gap in orthodontic-specific assessment. Identifying whether impaired cervical proprioception is associated with bruxism risk and pain may help expand orthodontic screening beyond dental alignment alone and support a more integrated clinical approach. Therefore, this study aimed to determine the frequency of cervical joint position error among orthodontic patients and to examine its association with bruxism risk and pain severity. It was hypothesized that positive cervical joint position error would be significantly associated with higher bruxism risk and greater pain severity among orthodontic patients.

MATERIALS AND METHODS

Study design and setting

This cross-sectional observational study was conducted among orthodontic patients recruited from dental hospitals and clinical settings in Lahore, Pakistan. The study was designed to evaluate the association between cervical joint position error, bruxism risk, and pain severity in patients receiving or having recently received orthodontic or dental-related treatment. Data collection was completed over an estimated four-month period in a supervised clinical environment.

Participants and sampling

A non-probability convenience sampling technique was used. The required sample size was calculated using Rao-soft software at a 95% confidence interval and 5% margin of error, yielding a final sample of 115

participants. Eligible participants included male and female orthodontic patients aged 13–60 years who had recent orthodontic conditions, dental anomalies, parafunctional oral habits, or were undergoing treatment or post-treatment care for dental or orthodontic problems. Participants were excluded if they had neurological disorders affecting proprioception, a history of cervical spine injury or surgery, chronic neck pain, use of medications that could affect neuromuscular or proprioceptive function, pregnancy or any condition interfering with study procedures, or any psychiatric condition that could affect participation or reporting.

Cervical joint position error assessment

Cervical proprioception was assessed using the Cervical Joint Position Error test. During the test, a laser pointer was fixed to the participant's head and projected onto a target placed at a standardized distance of approximately 90 cm. Participants were instructed to perform controlled cervical movements, including rotation, flexion, and extension, and then return the head to the neutral starting position. The distance between the original target point and the returned laser point was recorded as the repositioning error. This linear error distance was converted into angular displacement using the formula $\varepsilon = \tan^{-1}(d/r)$, where d represents the measured error distance and r represents the distance from the participant to the target. A lower angular error indicated better cervical joint position sense. For analysis, cervical joint position error was categorized as negative or positive, with error greater than 4.5° considered clinically meaningful and coded as positive.

Bruxism risk assessment

Bruxism risk was assessed using the Bruxism Evaluation Questionnaire. This self-report instrument evaluates oral parafunctional behaviors, including tooth clenching, grinding, jaw tension, and symptoms related to awake and sleep bruxism. The questionnaire was administered under researcher supervision to ensure that participants understood each item and completed the tool appropriately. Total BEQ scores were categorized using the predefined threshold, where a score below 15 indicated no bruxism risk and a score above 15 indicated high bruxism risk.

Pain assessment

Pain severity was measured using the Visual Analogue Scale. Participants marked their perceived pain intensity on a 10-cm horizontal line anchored by "no pain" at one end and "worst imaginable pain" at the other. Scores were categorized into mild pain, moderate pain, and severe pain using the study's predefined groupings: 0–3 for mild pain, 4–6 for moderate pain, and 7–10 for severe pain. The VAS was selected because it provides a simple, clinically interpretable measure of pain intensity suitable for observational clinical research.

Companion manuscript disclosure

Masticatory function was also assessed in the parent study using the Chewing Function Questionnaire; however, masticatory performance and its association with bruxism and pain are reported in a separate companion manuscript. The present manuscript is restricted to cervical joint position error as the primary exposure and its association with bruxism risk and pain severity as the principal outcomes.

Data collection procedure

After ethical approval, eligible participants were approached in the selected dental settings and informed about the study purpose, assessment procedures, voluntary nature of participation, and confidentiality of responses. Written informed consent was obtained before data collection. Participants first completed the self-reported questionnaires, including the Bruxism Evaluation Questionnaire and Visual Analogue Scale, under supervision. The CJPE test was then performed in a controlled clinical setting. All participant data were coded and entered anonymously to preserve confidentiality.

Statistical analysis

Data were entered and analyzed using IBM SPSS Statistics version 27.0.1. Descriptive statistics were calculated for demographic and clinical variables, including frequencies, percentages, means, and standard deviations where appropriate. The frequency of positive and negative CJPE, bruxism risk

categories, and pain severity categories was reported. Pearson's chi-square test was used to examine the association between CJPE status and bruxism risk, and between CJPE status and pain severity. Fisher's exact test was considered where expected cell counts required exact testing. Linear-by-linear association was used where ordinal trends were relevant. Statistical significance was set at $p < 0.05$.

Ethical considerations

The study was conducted after ethical approval from the relevant institutional authority. Written informed consent was obtained from all participants before participation. Participants were informed that their involvement was voluntary and that they could withdraw from the study at any point without penalty. Confidentiality was maintained by anonymizing and coding all collected data.

RESULTS

A total of 115 orthodontic patients were included in the analysis, with no missing data for the demographic or primary clinical variables. Most participants were young adults aged 13–39 years, comprising 98 participants (85.2%) of the sample. Females represented a larger proportion of the cohort than males, with 69 female participants (60.0%) and 46 male participants (40.0%). Regarding body mass index, most participants were in the normal BMI category, followed by overweight, underweight, and obese categories.

Table 1. Baseline characteristics of the study participants

Variable	Category	Frequency (n)	Percentage (%)
Age group	13–39 years	98	85.2
	40–59 years	14	12.2
	≥60 years / older adult category	3	2.6
Gender	Male	46	40.0
	Female	69	60.0
Body mass index	Underweight	13	11.3
	Normal weight	67	58.3
	Overweight	26	22.6
	Obese	9	7.8

Cervical joint position error was positive in 56 participants (48.7%) and negative in 59 participants (51.3%). Bruxism risk was high in 88 participants (76.5%), while 27 participants (23.5%) were classified as having no bruxism risk. On the Visual Analogue Scale, 53 participants (46.1%) reported mild pain, 44 participants (38.3%) reported moderate pain, and 18 participants (15.7%) reported severe pain.

Table 2. Distribution of cervical joint position error, bruxism risk, and pain severity

Variable	Category	Frequency (n)	Percentage (%)
Cervical joint position error	Negative	59	51.3
	Positive	56	48.7
Bruxism risk classification	No risk of bruxism, BEQ <15	27	23.5
	High risk of bruxism, BEQ >15	88	76.5
Pain severity, VAS	Mild pain, 0–3	53	46.1
	Moderate pain, 4–6	44	38.3
	Severe pain, 7–10	18	15.7

A statistically significant association was observed between cervical joint position error and bruxism risk. Among participants with positive CJPE, 54 out of 56 participants (96.4%) were classified as having high bruxism risk, compared with 34 out of 59 participants (57.6%) in the CJPE-negative group. Pearson's chi-square test confirmed a significant association between CJPE status and BEQ risk classification, $\chi^2(1) = 24.076$, $p < 0.001$. The effect size was moderate to strong, with Cramer's $V = 0.458$. Based on the cross-tabulated counts, participants with positive CJPE had approximately 19.85 times higher odds of being classified as high risk for bruxism than participants with negative CJPE.

Table 3. Association between cervical joint position error and bruxism risk

CJPE status	No risk of bruxism, BEQ <15 n (%)	High risk of bruxism, BEQ >15 n (%)	Total
Negative	25 (42.4)	34 (57.6)	59
Positive	2 (3.6)	54 (96.4)	56
Total	27 (23.5)	88 (76.5)	115

Chi-square statistics

Test	Value	df	p-value
Pearson chi-square	24.076	1	<0.001
Continuity correction	21.965	1	<0.001
Likelihood ratio	27.678	1	<0.001
Fisher's exact test	—	—	<0.001
Linear-by-linear association	23.867	1	<0.001

Note: Percentages are row percentages for CJPE categories. Cramer's V = 0.458. Odds ratio for high bruxism risk in CJPE-positive versus CJPE-negative participants = 19.85.

A significant association was also found between CJPE status and pain severity. In the CJPE-negative group, most participants reported mild pain, whereas participants with positive CJPE were more frequently distributed in the moderate and severe pain categories. Specifically, 41 of 56 CJPE-positive participants (73.2%) reported moderate-to-severe pain compared with 21 of 59 CJPE-negative participants (35.6%). Pearson's chi-square test showed a statistically significant association between CJPE and VAS pain categories, $\chi^2(2) = 17.743$, $p < 0.001$. The ordinal trend was also significant, suggesting that positive CJPE was associated with increasing pain severity. Cramer's V was 0.393, indicating a moderate association. When pain was dichotomized as mild versus moderate-to-severe, participants with positive CJPE had approximately 4.95 times higher odds of reporting moderate-to-severe pain than those with negative CJPE.

Table 4. Association between cervical joint position error and pain severity

CJPE status	Mild pain, VAS 0–3 n (%)	Moderate pain, VAS 4–6 n (%)	Severe pain, VAS 7–10 n (%)		Total
Negative	38 (64.4)	17 (28.8)	4 (6.8)		59
Positive	15 (26.8)	27 (48.2)	14 (25.0)		56
Total	53 (46.1)	44 (38.3)	18 (15.7)		115
Test		Value	df	p-value	
Pearson chi-square		17.743	2	<0.001	
Likelihood ratio		18.419	2	<0.001	
Linear-by-linear association		16.924	1	<0.001	

Note: Percentages are row percentages for CJPE categories. Cramer's V = 0.393. Odds ratio for moderate-to-severe pain in CJPE-positive versus CJPE-negative participants = 4.95.

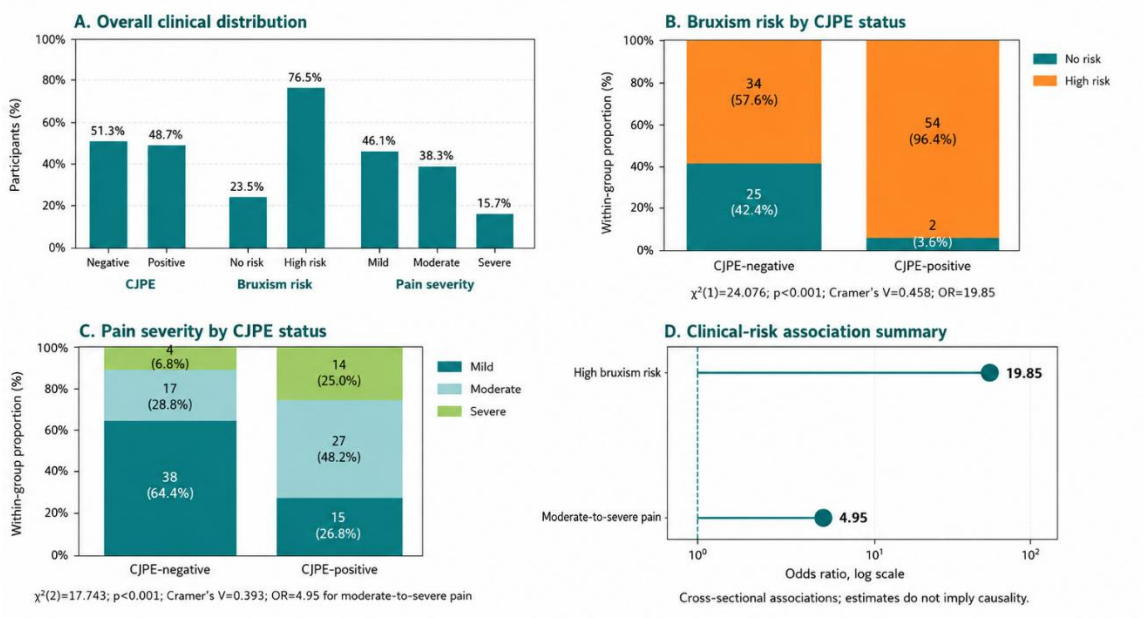

Figure 1. Multi-panel visualization of cervical joint position error, bruxism risk, and pain severity among orthodontic patients. Panel A shows the overall distribution of cervical joint position error status, bruxism risk classification, and pain severity categories in the total sample. Panel B demonstrates that high bruxism risk was more frequent among participants with positive cervical joint position error than those with negative cervical joint position error. Panel C shows a shift toward moderate and severe pain among participants with positive cervical joint position error. Panel D summarizes the strength of cross-sectional associations, indicating higher odds of high bruxism risk and moderate-to-severe pain in participants with positive cervical joint position error. CJPE, cervical joint position error; OR, odds ratio.

Overall, the findings indicate that nearly half of the orthodontic patients demonstrated positive cervical joint position error. Positive CJPE was significantly associated with both elevated bruxism risk and greater

pain severity. These results support the proposed sensorimotor relationship between impaired cervical proprioception, parafunctional jaw activity, and pain among orthodontic patients.

DISCUSSION

The present study investigated the relationship between cervical joint position error, bruxism risk, and pain severity among orthodontic patients and demonstrated significant associations between impaired cervical proprioception and both elevated bruxism risk and greater pain intensity. Nearly half of the participants exhibited positive cervical joint position error, while more than three-quarters of the sample were categorized as having high bruxism risk. Participants with positive CJPE showed markedly greater odds of belonging to the high-risk bruxism category and were substantially more likely to report moderate-to-severe pain. These findings support the concept that cervical sensorimotor dysfunction may contribute to parafunctional jaw activity and pain amplification within the cranio-cervico-mandibular complex. The results also reinforce the view that orthodontic patients should not be evaluated solely from an occlusal perspective because neuromuscular and proprioceptive disturbances may influence treatment experience, symptom burden, and functional adaptation.

Several neurophysiological mechanisms may explain the observed associations. The cervical spine and masticatory system are connected through trigemino-cervical convergence, where cervical afferents and trigeminal sensory pathways interact within the brainstem. Altered cervical proprioceptive input may therefore influence mandibular motor control and muscle activation patterns. Deep cervical muscles possess a high density of muscle spindles that contribute to head orientation and postural stabilization, and disturbances in this proprioceptive feedback may result in maladaptive neuromuscular compensation involving the jaw and cervical musculature. Increased co-activation of neck and jaw muscles may subsequently enhance clenching behavior, muscular fatigue, and pain sensitization. Furthermore, prolonged parafunctional activity may perpetuate abnormal cervical muscle recruitment and reinforce a cycle of sensorimotor dysfunction. Central sensitization mechanisms may also contribute to the relationship between cervical dysfunction and pain severity, particularly in patients experiencing persistent parafunctional loading and muscular hyperactivity. These interconnected mechanisms collectively support the interpretation that cervical proprioceptive impairment is not an isolated finding but rather part of a broader neuromuscular disturbance involving head, neck, and mandibular control.

The findings of this study are consistent with previous literature examining cervical dysfunction and bruxism-related disorders. Elmesseh et al. reported statistically significant associations between bruxism-related temporomandibular dysfunction and altered cervical proprioception, although the magnitude of correlation observed in their study was weaker than that found in the present orthodontic cohort (3). The stronger association observed in the current study may be related to the additional biomechanical and proprioceptive alterations produced by orthodontic treatment and occlusal modification. Similarly, Gouw et al. demonstrated coherence between jaw and neck muscle activity during sleep bruxism, supporting the existence of coordinated neuromuscular behavior between cervical and masticatory systems (2). The present findings extend this concept by showing that impaired cervical joint position sense is clinically associated with higher bruxism risk and pain severity in orthodontic patients. Peng et al. emphasized the importance of cervical proprioception in maintaining neuromuscular coordination and postural control in neck pain populations, and the current findings suggest that these principles may also apply to orthodontic and craniofacial dysfunction (1). In addition, evidence linking bruxism to muscular fatigue, altered motor control, and temporomandibular symptoms further supports the biological plausibility of the observed relationships.

The clinical implications of these findings are important for orthodontic assessment and management. Orthodontic care traditionally emphasizes occlusal correction and dental alignment; however, the current results suggest that cervical proprioceptive dysfunction may contribute to parafunctional habits and pain-related outcomes during treatment. Incorporating cervical joint position testing into orthodontic evaluation may assist clinicians in identifying patients at increased risk of bruxism and pain complications. Screening for cervical dysfunction before and during orthodontic treatment may allow earlier implementation of

preventive or rehabilitative strategies. A multidisciplinary approach involving orthodontists, physiotherapists, and orofacial pain specialists may therefore improve patient management and treatment outcomes. Furthermore, assessment of pain severity alongside proprioceptive evaluation may help identify patients who require additional neuromuscular rehabilitation or behavioral interventions. Consideration of cervical posture and sensorimotor control may also contribute to improving post-treatment stability and reducing symptom persistence in susceptible individuals.

This study has several strengths. It focused specifically on an orthodontic population, used validated clinical and questionnaire-based assessment tools, and evaluated multiple clinically relevant variables within the same cohort. The sample size was adequate for detecting statistically significant associations, and standardized CJPE procedures were used to evaluate cervical proprioception. Nevertheless, several limitations should be acknowledged. The cross-sectional design prevents causal inference and does not establish whether cervical proprioceptive dysfunction precedes or results from bruxism and pain. Convenience sampling and recruitment from a single city may limit generalizability to broader populations. Bruxism risk was assessed using a self-reported questionnaire rather than polysomnography or electromyographic confirmation, which may introduce reporting bias. In addition, psychological stress, sleep quality, treatment duration, and orthodontic device-specific effects were not controlled despite their potential influence on bruxism behavior and pain perception. Minor variability in laser-guided CJPE measurements may also have affected proprioceptive classification. Future longitudinal and interventional studies using objective bruxism assessment methods are therefore recommended to further clarify causal relationships and therapeutic implications.

CONCLUSION

Cervical joint position error was significantly associated with both increased bruxism risk and greater pain severity among orthodontic patients. Participants with impaired cervical proprioception demonstrated substantially higher odds of high-risk bruxism behavior and moderate-to-severe pain compared with those without CJPE impairment. These findings support the concept that the cranio-cervico-mandibular region functions as an integrated neuromuscular system in which cervical sensorimotor dysfunction may influence parafunctional jaw activity and pain perception. Incorporating cervical proprioceptive assessment into orthodontic evaluation protocols may improve early identification of high-risk patients and support multidisciplinary management approaches involving orthodontic, physiotherapeutic, and pain-focused interventions. Further longitudinal studies using objective bruxism assessment tools are required to confirm causality and evaluate targeted rehabilitative strategies.

REFERENCES

1. Peng B, Yang L, Li Y, Liu T, Liu Y. Cervical proprioception impairment in neck pain: pathophysiology, clinical evaluation, and management. Pain Ther. 2021;10(2):1437-1458.
2. Gouw S, Frowein A, Wetselaar P, de Wijer A, Lobbezoo F. Coherence of jaw and neck muscle activity during sleep bruxism. J Oral Rehabil. 2020;47(4):432-440.
3. Elmesseh OIA, El-Sayyad MM, Ahmed SE. Correlation between bruxism and cervical function. Bull Fac Phys Ther. 2024;29(1):42.
4. Gulzar M, Fida M, Shaikh A. Self-reported bruxism in patients undergoing orthodontic treatment: a cross-sectional study. BMC Oral Health. 2024;24(1):1577.
5. Michelotti A, Rongo R, D'Antò V, Bucci R. Occlusion, orthodontics, and temporomandibular disorders: cutting edge of the current evidence. J World Fed Orthod. 2020;9(3 Suppl):S15-S18.
6. Pietrobon R, Coeytaux RR, Carey TS, Richardson WJ, DeVellis RF. Standard scales for measurement of functional outcome for cervical pain or dysfunction: a systematic review. Spine. 2002;27(5):515-522.
7. Hardy RS, Bonsor SJ. The efficacy of occlusal splints in the treatment of bruxism: a systematic review. J Dent. 2021;108:103621.

8. Riley P, Glenny AM, Worthington HV, Littlewood A, Clarkson JE, McCabe MG. Oral splints for patients with temporomandibular disorders or bruxism: a systematic review and economic evaluation. Health Technol Assess. 2020;24(7):1-224.

9. Kilinc HE, Onan D, Ergun N. Investigation of masticatory muscle thickness and mechanosensitivity of cervical and masticatory muscles in myofascial temporomandibular disorder patients with bruxism: a cross-sectional study. Musculoskelet Sci Pract. 2024;70:102919.

10. Lee YH. Relationship analogy between sleep bruxism and temporomandibular disorders in children: a narrative review. Children (Basel). 2022;9(10):1466.

11. Nykänen L, Manfredini D, Lobbezoo F, Ahlberg J. Assessment of awake bruxism by a novel bruxism screener and ecological momentary assessment among patients with masticatory muscle myalgia and healthy controls. J Oral Rehabil. 2024;51(1):162-169.

12. Chanteux S, Taut C, Popescu SM. Self-assessment questionnaire and clinical evaluation of bruxism in correlation with perceived stress. Rom J Stomatol. 2024;70:46-51.

13. Smaglyuk L, Liakhovska A, Trofymenko M. EMG-characteristics of masticatory muscles in subjects with bruxism. Ukr Dent Almanac. 2022;(1):43-49.

14. Vlăduțu DE, Ionescu E, Perlea P, Tănase G, Burlibașa M. Ecological momentary assessment of masseter muscle activity in patients with bruxism. Int J Environ Res Public Health. 2022;20(1):581.

15. Lan KW, Jiang SS, Wang CH, Chen YJ. Comparative study of surface electromyography of masticatory muscles in patients with different types of bruxism. World J Clin Cases. 2022;10(20):6876-6887.

16. Chattrattrai T, Aarab G, Lobbezoo F. Network analysis of sleep bruxism in the EPISONO adult general population. J Sleep Res. 2024;33(2):e13957.

17. Heleiwa-Ferioli T, de la Cruz Vigo S. Association between bruxism and the use of aligners in orthodontics. J Clin Exp Dent. 2024;16(10):e1247-e1254.

18. Bortoletto CC, Kobayashi FY, Costa YM, Conti PCR. Evaluation of muscle activity and bite force in masticatory muscle after massage therapy or occlusal splint in sleep bruxism childhood. Res Soc Dev. 2021;10(3):e38810313468.

19. Araya Zavala S, Barrientos Reyes J, Pavez M. Bruxism and masticatory pattern: an understudied relationship. Jaw Funct Orthop Craniofac Growth. 2022;2(2):86-97.

20. Wieckiewicz M, Martynowicz H, Smardz J, et al. Moving beyond bruxism episode index: discarding misuse of the number of sleep bruxism episodes as masticatory muscle pain biomarker. J Sleep Res. 2025;34(1):e14301.

21. Persic S, Palac A, Bunjevac T, Celebic A. Development of a new chewing function questionnaire (CFQ): factor analysis. Coll Antropol. 2012;36(4):1179-1186.

22. Armijo-Olivo S, Rappoport K, Fuentes J, et al. Head and cervical posture in patients with temporomandibular disorders. J Orofac Pain. 2011;25(3):199-209.

23. de Wijer A, Steenks MH, Bosman F, Helders PJM, Faber JAJ. Symptoms of the cervical spine in temporomandibular and cervical spine disorders. J Oral Rehabil. 1996;23(11):742-750.

24. Fernández-de-las-Peñas C, Cuadrado ML, Arendt-Nielsen L, Pareja JA. Myofascial trigger points and sensitization: an updated pain model for tension-type headache. Cephalalgia. 2007;27(5):383-393.

25. Treleaven J. Sensorimotor disturbances in neck disorders affecting postural stability, head and eye movement control. Man Ther. 2008;13(1):2-11.

26. Kristjansson E, Treleaven J. Sensorimotor function and dizziness in neck pain: implications for assessment and management. J Orthop Sports Phys Ther. 2009;39(5):364-377.

27. Lobbezoo F, Ahlberg J, Raphael KG, et al. International consensus on the assessment of bruxism: report of a work in progress. J Oral Rehabil. 2018;45(11):837-844.