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Temporomandibular disorders,Occlusal interference, Wear facets,Acquired flatfoot,Foot posture,Prosthodontics,Oral rehabilitation.

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Evaluation of the Association of Temporomandibular Disorders with Occlusal Interferences, Wear Facets and Acquired Flat Foot: A Cross-sectional study

Abstract

Background: Temporomandibular disorders (TMDs) affect the temporomandibular joint and masticatory system and may influence mandibular position, occlusal stability, and prosthodontic rehabilitation. Functional disturbances within the stomatognathic system may also be associated with postural adaptations.

Aim: To evaluate the association of TMDs with occlusal interferences, occlusal wear facets, and acquired flatfoot.

Materials and Methods: This cross-sectional study included 50 participants aged 18–40 years, divided into a TMD group (n=25) and a control group (n=25). TMD was diagnosed using the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) Axis I protocol. Premature contacts and occlusal interferences were assessed using articulating paper, and wear facets were clinically evaluated. Foot posture was assessed using Clarke's angle obtained from footprint analysis.

Results: Participants with TMD demonstrated a higher prevalence of occlusal interferences and wear facets than controls. A significant association was observed between TMD and altered medial longitudinal arch morphology, with a greater prevalence of moderate and severe flatfoot among participants with TMD ($p<0.001$).

Conclusion: TMDs are associated with functional occlusal alterations and acquired flatfoot, supporting a potential relationship between stomatognathic dysfunction and postural adaptation. Assessment of TMJ function, occlusion, and postural parameters may improve prosthodontic diagnosis and the predictability of comprehensive oral rehabilitation.

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INTRODUCTION

A stable and balanced body posture is fundamental for maintaining overall musculoskeletal health. Posture refers to the position and orientation of the human body in space.[1] Stability in posture is achieved through precise neuromuscular coordination of all body segments. Posture depends on several factors, including cervical alignment, lumbar tilt, pelvic positioning, knee alignment, and foot posture. [2] The stomatognathic system, comprising the temporomandibular joints (TMJs), masticatory muscles, dentition, and associated craniofacial structures, plays an important role in functional adaptation and postural regulation due to its close relationship with cervical and neuromuscular systems.[3] Temporomandibular disorders (TMDs) represent a group of musculoskeletal conditions affecting the TMJ, masticatory muscles, and related structures. Signs and symptoms of TMD have been reported in approximately 20–30% of adults, particularly among individuals between 20 and 40 years of age.[4] In prosthodontic and restorative dentistry, accurate evaluation of TMJ function, mandibular position, occlusal relationships, and neuromuscular stability is essential for successful diagnosis and treatment planning.

Occlusion represents an important functional interface between the stomatognathic system and neuromuscular control. Harmonious occlusal contacts allow coordinated mandibular movements and balanced muscle activity.[5] Occlusal wear facets may represent evidence of prolonged mechanical stress or parafunctional activity. However, occlusal interferences, premature contacts, and abnormal wear patterns may disturb mandibular function and contribute to altered muscle activity.[5,6]

Foot posture is primarily determined by the contour of the medial longitudinal arch.[7] Low-arched feet may be congenital or acquired, with acquired flatfoot (progressive collapsing foot deformity) developing in adulthood and associated with pain, functional impairment, gait alterations, and progressive foot deformities.[8,9] Previous studies have reported associations between temporomandibular disorders (TMDs) and musculoskeletal alterations, including forward head posture, pelvic and spinal misalignment, knee abnormalities, altered foot architecture, and impaired postural stability.[2,10,11] These findings are supported by the tensegrity theory, which proposes that mechanical forces are transmitted throughout the body via interconnected fascial and neuromuscular networks.[12] However, the relationship between TMDs, occlusal dysfunction, and acquired flatfoot remains poorly understood. Therefore, the present study aimed to evaluate the association between temporomandibular disorders, occlusal interferences, wear facets, and acquired flatfoot, with potential implications for prosthodontic diagnosis, treatment planning, and oral rehabilitation.

METHODOLOGY

The study was conducted after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants before enrolment. The cross-sectional study included 50 participants, with 25 in the control group (without signs and symptoms of TMDs) and 25 in the test group (with signs and symptoms of TMDs). The sample size was calculated using G*Power software based on the prevalence of flat right foot observed in the pilot study (6.67% in subjects without TMD and 66.7% in subjects with TMD and occlusal interferences). Twenty percent of the total sample size was reserved for validation of the classification tool.

Inclusion criteria: individuals between 18–40 years of age, with and without signs and symptoms of TMD, ability to understand and provide informed consent, have no limitation in performing mandibular movements or footprint assessment

Exclusion criteria: Participants with a history of congenital flat foot (participants unaware of the same were excluded), facial or mandibular trauma, orthognathic surgery, systemic rheumatic illness, neurologic or muscular disorders, psychosomatic or psychiatric diseases, physical or mental disability, or prior physiotherapy and speech therapy were excluded. Participants had the right to withdraw at any time, and their collected data were not included in the analysis.

Clinical Assessment Protocol

All clinical examinations were performed by a single calibrated examiner.

Participants were assigned unique identification codes to maintain confidentiality and minimize assessment bias.

The examiner performing foot posture evaluation was blinded regarding the TMD status of the participant.

Clinical evaluation and data collection

Data was collected after informed consent was obtained. TMD symptoms were evaluated using a closed-ended, self-administered questionnaire for initial screening, based on the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD, 2014)[13]. The Signs and symptoms of TMD were evaluated and confirmed using DC/TMD Axis I by a single examiner.(Fig.1)

Fig.1: Extra auricular examination of TMJ

Clinical assessment according to the DC/TMD Axis I protocol included evaluation of TMJ pain, muscle tenderness, mandibular movement, joint sounds, and pain during mandibular function for confirmation of TMD diagnosis. Participants who reported symptoms and were confirmed clinically were placed in the test group, while asymptomatic participants were included in the control group.

Occlusal Assessment

Assessment of occlusal interferences was done using Bausch 40 µm articulating paper (Fig.2,3).[14] Occlusal contacts were evaluated in maximum intercuspation position, protrusion, and lateral excursion.[15] Occlusal interferences were classified as: Centric interference, working side interference, non-working side interference, and protrusive interference. The presence or absence of occlusal interference was recorded for each participant.

Fig.2: Evaluation of occlusal interferences with Bausch 40 micron articulating paper

Fig 3.Occlusal interferences noted in distal cusp region of 46,47

Assessment of Occlusal Wear Facets

Occlusal wear facets were evaluated clinically under adequate illumination.(Fig.4)

The following parameters were recorded:

1. Presence of Wear Facets

Participants were classified as:

Wear facets were graded clinically as:

- Mild: minimal enamel wear without significant anatomical alteration.
- Moderate: visible flattening of cusps or incisal edges.
- Severe: extensive wear involving dentin exposure or significant occlusal morphology alteration.

Fig 4.Showing wear facets 37,38,47,48 region

Evaluation of foot posture

The medial longitudinal arch was assessed using Clarke's angle(Fig.5). Participants were asked to dip their feet in water, and simultaneous footprints of both feet were recorded on an absorbent brown cardboard. Two points were marked: one on the medial border line and the other on the medial-most point of the arch. A tangent was drawn to both the points, and the angle formed between them was measured using a goniometer. (Fig.6) Two consecutive prints were taken, and the average value was recorded. Based on Clarke's angle, feet were classified as:[16]

- Flatfoot/ severe pronation (0–29.9 degrees)
- Moderate flatfoot/pronation (30–34.9 degrees)
- Intermediate (physiological flatfoot and normal) (35–42 degrees)
- Normal foot (normal to cavus) (>42 degrees)

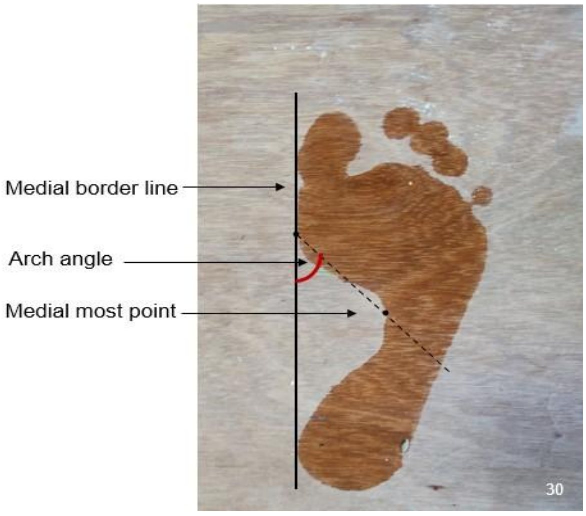

Fig.5: Clark's angle measured on the footprint

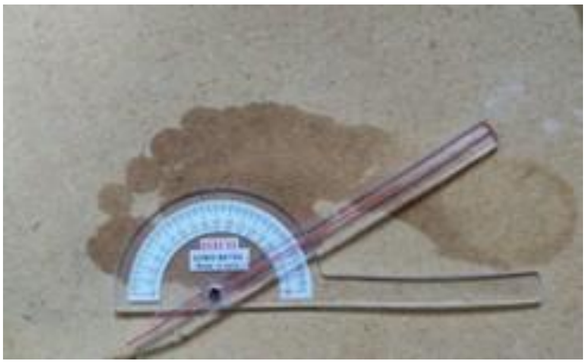

Fig.6: Goniometer used to measure the Clark's angle

Validation of the footprint-based classification method (cardboard imprint) was done by using plaster footprints(Fig.7) for 20% of the total sample size. The prevalence of flatfoot in both study groups (TMD and control) was compared using a Z-test for two proportions.

Fig.7: Plaster index for validation of the method

Statistical analysis

Data were analyzed using descriptive and inferential statistics. Quantitative variables were expressed as mean ± standard deviation or median with interquartile range, while categorical variables were presented as frequencies and percentages. The Student's t-test was used to compare continuous variables between groups, and the Chi-square test was applied to determine associations between categorical variables. To ensure the reliability of the footprint-based classification method (cardboard imprint), the prevalence of flatfoot in both study groups (TMD and control) was compared using a Z-test for two proportions. Correlation analysis to evaluate association between occlusal interference, wear facets and Clarke's angle values. Statistical significance was set at $p < 0.05$

RESULT

A total of 50 participants were included in the present cross-sectional study. Based on DC/TMD Axis I evaluation, participants were categorized into a TMD group (n=25) and a control group (n=25). All participants underwent assessment of temporomandibular function, occlusal characteristics, and foot posture evaluation.

There was no statistically significant association between the study groups and demographic characteristics, including age, sex distribution, and body mass index (p>0.05) (Table 1).

Table 1 The demographic characteristics of TMD and Control group

Variables	TMD Group (n=25)	Control Group (n=25)	p value
Age (years), Mean ± SD	28.4 ± 5.6	27.9 ± 5.2	0.74
Male, n (%)	12 (48%)	13 (52%)	0.78
Female, n (%)	13 (52%)	12 (48%)	
Mean BMI (kg/m²)	23.1 ± 2.8	22.8 ± 2.6	0.68

There was a statistically significant association between the test group and the presence of occlusal interferences. A greater number of participants in test group exhibited occlusal interferences (60%) compared with controls (20%) (p=0.004). Among the test group participants with occlusal interferences, centric interference was the most frequently observed (46.7%)(Table 2).

Table 2. Association Between Temporomandibular Disorders and Occlusal Interference

Occlusal Interference	TMD Group (n=25)	Control Group (n=25)	Total (n=50)	p value
Present	15 (60%)	5 (20%)	20 (40%)	0.004
Absent	10 (40%)	20 (80%)	30 (60%)	
Total	25 (100%)	25 (100%)	50 (100%)	

There was a statistically significant association between the test group and the presence of occlusal wear facets. A greater number of test group participants exhibited occlusal wear facets (52%) compared with controls (16%) (p=0.008). Among the test group participants with occlusal wear facets, mild wear was most frequently observed (46.2%), followed by moderate (38.5%) and severe wear facets (15.3%) (Table 3).

Table 3. Association Between Temporomandibular Disorders and Occlusal Wear Facets

Occlusal Wear Facets	TMD Group (n=25)	Control Group (n=25)	Total (n=50)	p value
Present	13 (52%)	4 (16%)	17 (34%)	0.008
Absent	12 (48%)	21 (84%)	33 (66%)	
Total	25 (100%)	25 (100%)	50 (100%)	

There was a statistically significant association between occlusal alterations and altered foot posture. A greater number of participants with occlusal interferences exhibited acquired flatfoot (60%) compared with those without occlusal interferences (26.7%) (p=0.02). Similarly, participants with occlusal wear facets demonstrated a greater prevalence of altered medial longitudinal arch morphology, with moderate-to-severe wear facets showing a higher tendency toward flatfoot (Table 4).

Table 4. Association Between Occlusal Dysfunction and Foot Posture Alteration

Clinical Parameter	Normal Foot Posture n (%)	Altered Foot Posture n (%)	P value
Occlusal interference absent (n=30)	22 (73.3%)	8 (26.7%)	0.02
Occlusal interference present (n=20)	8 (40%)	12 (60%)	
Wear facets absent (n=33)	25 (75.8%)	8 (24.2%)	0.003
Wear facets present (n=17)	5 (29.4%)	12 (70.6%)	

The association between temporomandibular joint disorder (TMD) and acquired flat foot was analyzed for both the right and left feet using the Fisher-Freeman-Halton Exact Test, due to small cell counts in contingency tables. A p-value < 0.05 was considered statistically significant.

There is a statistically significant association between the test group and acquired flat foot (right). A greater number of cases exhibited severe flatfoot (40%) and moderate flat foot(28%), while controls showed mild flatfoot (52%) or a normal arch (20%) with a test statistic value of 11.957,p value=0.006(Table 5)

Table 5. Association between Temporomandibular Disorders and Severity of Acquired Flatfoot in the Right Foot

		Normal	Mild Flatfoot	Moderate Flatfoot	Severe Flatfoot	Total
Test	Count	1	7	7	10	25
	% within Group	4.0%	28.0%	28.0%	40.0%	100.0%
Control	Count	5	13	6	1	25
	% within Group	20.0%	52.0%	24.0%	4.0%	100.0%

Test statistic value=11.957 p value=0.006

A statistically significant association was observed for the left foot as well. 40% of the test group had severe flatfoot,36% with moderate flat foot compared to 0% in controls, while controls predominantly had mild flatfoot (56%) or normal arches (16%) with 0% severe flat foot, with a test statistic value of 17.583, p value <0.001(table 6)

Table 6. Association between Temporomandibular Disorders and Severity of Acquired Flatfoot in the Left Foot

		Normal	Mild Flatfoot	Moderate Flatfoot	Severe Flatfoot
Test	Count	2	4	9	10
	% within Group	8.0%	16.0%	36.0%	40.0%
Control	Count	4	14	7	0
	% within Group	16.0%	56.0%	28.0%	0.0%

DISCUSSION

The present cross-sectional study evaluated the association between temporomandibular disorders (TMDs), occlusal interferences, occlusal wear facets, and acquired flatfoot. Occlusal interferences and wear facets were assessed as functional variables that may contribute to the neuromuscular adaptations linking the stomatognathic system with whole-body posture.

The findings demonstrated a higher prevalence of occlusal interferences among individuals with TMD. Occlusal interference was identified in 60% of participants with TMD compared with only 20% of participants without TMD (Table 2). Similarly, 52% of participants with TMD demonstrated clinically detectable occlusal wear facets (Table 3). These findings are comparable to those of Lekaviciute et al., who highlighted the association between malocclusion, bruxism, tooth loss, and temporomandibular disorders, emphasizing the importance of comprehensive occlusal and TMJ assessment in clinical practice.[17]

This relationship may be explained by altered mandibular movement pathways associated with occlusal interferences, which can influence masticatory muscle activity and modify proprioceptive feedback from periodontal mechanoreceptors and the temporomandibular joint. Persistent occlusal interference may therefore contribute to neuromuscular adaptations involving both craniofacial and postural function.[5] Occlusal wear facets represent prolonged functional or parafunctional tooth contact and are frequently associated with bruxism and occlusal overload. This may increase muscle fatigue and contribute to occlusal instability and disturbances within the stomatognathic system.[18] Although occlusal discrepancies cannot be considered the sole etiological factor for TMD, their higher prevalence among symptomatic individuals suggests that they may influence the functional expression of these disorders.

The present study further evaluated the association between TMDs and postural alterations using the medial longitudinal arch of the foot as a clinical indicator. A statistically significant association was observed, with participants in the TMD group demonstrating a greater prevalence of severe flatfoot in both the right and left feet (Tables 5 and 6). Participants exhibiting occlusal interference and moderate-to-severe wear facets demonstrated a greater prevalence of acquired flat foot(Table 4),This finding is consistent with previous studies reporting a relationship between TMDs and postural alterations. Souza et al.[12] demonstrated altered plantar pressure distribution in individuals with TMD using baropodometric analysis. Similarly, Garstka et al. reported changes in foot arch parameters following mandibular repositioning with a temporary silicone occlusal splint, suggesting a possible interaction between mandibular position and postural balance.[2] Together, these findings support the concept that functional disturbances of the stomatognathic system may be associated with postural adaptations extending beyond the craniofacial region.

Within the limitations of the present study, an association between TMDs, occlusal interferences, occlusal wear facets, and postural alterations can be inferred. Although a causal relationship cannot be established, comprehensive evaluation of TMJ function and occlusion may therefore be important before definitive prosthodontic and restorative treatment. In patients with symptomatic postural alterations, multidisciplinary assessment and treatment planning may be considered to facilitate comprehensive patient management.

The present study has certain limitations. Its cross-sectional design does not establish causality, and foot posture was assessed using Clarke's angle rather than dynamic pedobarographic analysis. Computerized occlusal analysis and other factors influencing posture were also not evaluated.

Overall, the findings suggest an association between TMDs, occlusal disturbances, and postural alterations. Comprehensive functional evaluation and, where indicated, multidisciplinary assessment may support better clinical management.

CONCLUSION

Within the limitations of the present study, TMDs, occlusal interferences, and occlusal wear facets were significantly associated with alterations in foot posture. These findings suggest a possible relationship between stomatognathic dysfunction and postural adaptations. Comprehensive functional evaluation of the TMJ and occlusion may therefore be considered during prosthodontic assessment, with multidisciplinary evaluation in patients presenting with symptomatic postural alterations.

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