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Original Article

Impact of Orthodontic Treatment Timing for Distal Occlusion on Patients' Quality of Life

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ABSTRACT

This study evaluates the importance and effectiveness of the timely treatment of distal occlusion. The study involved 220 individuals aged 23 to 40 years, divided into four groups: 60 patients who underwent orthodontic treatment for distal occlusion before age 18; 60 patients treated at age 25-32 years; 60 untreated patients with distal occlusion; and 40 individuals with physiological occlusion as controls. All participants underwent a comprehensive examination, including cephalometric analysis, electromyography of masticatory muscles, ultrasound diagnostics of mandibular movements, three-dimensional spinal analysis, stabilometry, and questionnaire survey to assess subjective status and quality of life. The results demonstrated that distal occlusion is a systemic pathology involving the temporomandibular joint, masticatory muscles, airways, and musculoskeletal system, forming a stable vicious circle. Patients treated in adolescence showed no statistically significant differences from controls in most parameters. Patients treated at age 25-32 showed intermediate results, with significant improvement compared to untreated patients (headache frequency 41.7% vs 68.3%, neck pain 55.0% vs 81.7%) but residual postural disturbances, indicating the need for comprehensive rehabilitation in late referral cases. The findings justify timely orthodontic treatment not only from an aesthetic but also from a medical perspective to prevent systemic disorders and preserve quality of life.

Keywords: Distal occlusion, Malocclusion, Dentofacial anomalies, Orthodontic treatment, Postural disorders, Temporomandibular joint

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Introduction

Dentofacial anomalies represent one of the most pressing issues in modern dentistry, due not only to their high prevalence but also to their significant impact on patients' quality of life. These disorders are not isolated dental defects; rather, they constitute a complex set of morphofunctional changes affecting the dentofacial system, airways, musculoskeletal apparatus, and psychoemotional sphere [1, 2]. In the current scientific paradigm, dentofacial anomalies are viewed as systemic pathologies capable of initiating a

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cascade of compensatory-adaptive reactions, leading to the formation of stable pathological conditions, as confirmed by numerous clinical studies in recent decades [3-5].

Occlusion refers to the relationship between the dental arches when the teeth are in central occlusion, i.e., during maximum contact of antagonist teeth. Orthodontics distinguishes between physiological and pathological occlusion [6]. Physiological variants include orthognathic, straight, biprognathic, and physiological progenia, all of which ensure full masticatory and speech function along with harmonious facial aesthetics [7, 8]. Pathological forms include distal (prognathic), mesial (prognathic), deep, open, and crossbite [9, 10]. Each anomaly type has characteristic clinical features and exerts specific effects on the body as a whole. Distal occlusion, the focus of this study, is characterized by a discrepancy in the size or position of the jaws: the maxilla is overdeveloped or positioned anteriorly, while the mandible is underdeveloped or displaced distally [11, 12]. Clinically, this presents as a convex facial profile, a receding chin, lip strain during closure, and the subsequent development of mouth breathing habits, which trigger a chain of pathological changes throughout the body [13, 14].

The etiology of dentofacial anomalies is multifactorial. It combines genetically determined mechanisms with environmental risk factors. Key causes include hereditary predisposition. This may manifest as direct transmission of traits such as supernumerary teeth, agenesis, macrognathia, micrognathia, or jaw size discrepancies [15, 16]. Endogenous factors related to the antenatal period also play an important role. These include toxicosis, threatened miscarriage, anemia, difficult labor with neonatal asphyxia, and birth injuries [17, 18]. During the postnatal period, modifiable factors become significant. These include early artificial feeding, prolonged pacifier use, and impaired respiratory, swallowing, and speech functions. Harmful habits such as finger, tongue, or lip sucking and mouth breathing are also important [19, 20]. Among exogenous factors, the role of dental caries and its complications cannot be overlooked. Caries leads to premature loss of primary and permanent teeth. This almost invariably causes dental arch shortening and predisposes individuals to dentoalveolar deformities [21].

Analysis of epidemiological data across different time periods reveals distinct trends in the prevalence of dentofacial anomalies. These trends are important for planning preventive measures and organizing orthodontic care for the population. **Table 1** presents the detection rates of various malocclusion types over recent decades, compiled from epidemiological studies.

Table 1. Prevalence of Various Dentofacial Anomalies in the Population According to Studies from Different Decades (Percentage of Examined Individuals)

Anomaly Type	1960s	1980s	2000s	2020s
Distal occlusion	2-5	8-12	15-20	22-28
Deep bite	3-6	7-10	12-16	18-24
Open bite	1-2	2-3	3-5	4-6
Crossbite	2-3	3-5	5-8	7-11
Mesial occlusion	1-2	2-3	3-4	3-5
Dental crowding	10-15	18-25	30-35	35-42

As the data indicate, the prevalence of all malocclusion types has steadily increased over the past six decades [22]. The most pronounced rise has been in distal occlusion, deep bite, and dental crowding [23]. Specifically, the rate of distal occlusion has increased more than fivefold, from 2-5% in the 1960s to 22-28% in the current decade. Similar dynamics, although less pronounced, are observed for other pathology types. Dental crowding, one of the most frequent reasons for seeking orthodontic care, increased from 10-15% to 35-42% over the same period [24-26].

This trend likely reflects a combination of interrelated factors. First, improved diagnostic methods and the introduction of radiographic techniques (orthopantomography, cephalometry) into clinical practice allow the detection of even minor deviations that previously went unnoticed. Increased healthcare-seeking behavior, particularly due to rising aesthetic expectations regarding appearance, also plays a role. However, the most significant factors appear to be lifestyle changes in modern humans: predominance of soft, thermally processed foods requiring less active chewing, leading to underdevelopment of jaw bones; increased frequency of nasal breathing disorders due to higher rates of allergies and respiratory diseases; and the widespread adoption of harmful habits in childhood associated with prolonged use of electronic devices and sedentary behavior [27, 28]. Furthermore, the influence of deteriorating environmental conditions cannot be excluded, as these may adversely affect dentofacial system formation during prenatal development and early childhood [29, 30].

Particular attention should be paid to the fact that children with dentofacial anomalies exhibit various functional impairments significantly more often than children with physiological occlusion, confirming the

systemic nature of the pathology and the need for timely intervention. Recent studies indicate the involvement of epigenetic mechanisms in the development of dentofacial anomalies, opening new prospects for personalized prevention and treatment [31, 32]. However, to date, the timing of orthodontic treatment initiation remains the key factor for successful correction.

Thus, the relevance of studying long-term outcomes of orthodontic treatment for distal occlusion is beyond doubt. Of particular interest is the comparative analysis of correction effectiveness at different age periods and the assessment of the impact of timely treatment on patients' overall health, including not only the condition of the dentofacial system but also postural disorders, temporomandibular joint function, and overall quality of life. This study aims to evaluate the importance and effectiveness of timely treatment of distal occlusion through a comparative analysis of the clinical status of patients who received orthodontic care at different age periods and those who did not receive treatment.

Materials and Methods

The study was conducted at dental clinics in Grozny, Chechen Republic, from September 2023 to December 2025. A total of 220 participants born between 1985 and 2000 (aged 23-40 years at examination) were enrolled. Inclusion criteria for the main study groups were diagnosed distal occlusion in early adolescence (11-14 years), confirmed by medical records from Grozny dental institutions where patients initially sought care at that age. The diagnosis was verified through comprehensive clinical and radiographic examination performed during adolescence, including diagnostic dental cast analysis, lateral cephalometry with Schwarz analysis, and orthopantomography.

Participants with diagnosed distal occlusion were divided into three groups based on orthodontic treatment timing. Group 1 comprised 60 patients who underwent orthodontic treatment before age 18, during active facial skeleton growth, using fixed orthodontic appliances. Group 2 included 60 patients treated at age 25-32 years, after facial growth completion and when stable compensatory musculoskeletal changes had developed. Group 3 consisted of 60 patients with adolescent-diagnosed distal occlusion who received no orthodontic treatment throughout the follow-up period. Group assignment was based on medical records and anamnesis data obtained at enrollment.

The control group (Group 4) included 40 individuals with physiological (orthognathic) occlusion, with no current or previous dentofacial anomalies, matched for age and sex with the main groups. Absence of dentofacial anomalies was confirmed by clinical examination and radiography. Exclusion criteria for controls included a history of orthodontic treatment, orthodontic appliances, jaw surgery, or any complaints of temporomandibular joint dysfunction or chronic orofacial pain. The control group provided reference values for all parameters and enabled assessment of deviation magnitude in distal occlusion patients relative to treatment status.

The study design involved a comprehensive cross-sectional examination of all participants, assessing dentofacial status, temporomandibular joint function, musculoskeletal biomechanics, subjective patient-reported outcomes, and oral health-related quality of life. Standard dental examination included history taking, oral examination, and assessment of hard dental tissues, periodontium, and oral mucosa. To objectify occlusion and dentofacial relationships, diagnostic dental casts were fabricated from high-strength plaster and analyzed using an articulator. Occlusal contacts during central occlusion and various mandibular excursions were evaluated using Bausch articulating paper (8 and 12 μm thickness).

Radiographic examination included orthopantomography using a PaX-400C digital orthopantomograph (VATECH, South Korea) to assess teeth, jaw bones, temporomandibular joints, and paranasal sinuses. For cephalometric analysis, lateral cephalograms were obtained with the same device and processed using EzDent-i software, version 9.1. Cephalometric analysis followed standard methods, evaluating angular and linear parameters characterizing jaw, tooth, and facial soft tissue positions. Special attention was given to hyoid bone position and upper airway dimensions; additional measurements included distance from hyoid bone to vertebral plane and oropharyngeal airway space at the second cervical vertebra level.

Temporomandibular joint function was assessed using ultrasound mandibular movement diagnostics with the JMA (Jaw Motion Analyzer) system (Zebris Medical, Germany). This system provides three-dimensional analysis of mandibular movements with 0.1 mm accuracy, records condylar movement trajectories, and detects asymmetry and functional blocks. Concurrent electromyography of masseter and temporalis muscles was performed using surface electrodes with a Bio-EMG III device (BioResearch, USA). Electromyography was conducted at rest, during maximum voluntary clenching, and during functional tests.

To evaluate the impact of distal occlusion and orthodontic treatment on the musculoskeletal system, a

comprehensive postural examination was performed. Postural assessment used video analysis with the DIERS 4D motion Lab optical system (DIERS International, Germany), enabling three-dimensional spinal analysis in standing and dynamic positions without ionizing radiation. The system records spinous process positions, spinal segment inclination angles in frontal and sagittal planes, and pelvic and shoulder girdle torsion. Additionally, stabilometric assessment was performed using an ST-150 computerized stabiloanalyzer with biofeedback (NeuroLab LLC, Russia) to evaluate center of pressure position, balance function quality, and weight distribution between lower extremities. Stabilometry was performed in a standing position with eyes open and closed following standard protocols.

Oral health-related quality of life was assessed using the Russian-validated version of the OHIP-14 (Oral Health Impact Profile-14) questionnaire [33]. The instrument contains 14 items covering seven life aspects: functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability, and handicap. Each item is rated on a Likert scale from 0 (never) to 4 (very often); total scores range from 0 to 56, with higher scores indicating poorer quality of life. The questionnaire addressed the presence and severity of various symptoms potentially associated with long-standing dentofacial anomalies. Patients rated headache frequency and intensity, including migraine-like episodes, neck pain, thoracic back pain, and lumbar back pain, with particular attention to pain association with head position and prolonged static postures. Temporomandibular joint status was assessed through questions about clicking, crepitus, pain during mouth opening and chewing, and masticatory muscle fatigue at day's end.

Questions addressed patient satisfaction with dental status and smile aesthetics, as well as dental problems, including increased wear, enamel fractures, sensitivity, and frequency of dental visits for caries and complications over the past five years. Based on current understanding of chronic muscle tension effects on microcirculation and tissue trophism, we included questions on subjective assessment of facial skin quality, morning facial puffiness, nasolabial fold prominence, and perceived aging rate compared to peers. Assessment used a visual analog scale (0-10), with higher scores indicating greater satisfaction and slower perceived aging. Additional questions addressed general daytime fatigue, sleep quality, and post-waking energy levels using standardized sleep questionnaire items. Daytime sleepiness was assessed using the Epworth Sleepiness Scale, adapted for self-administration. The questionnaire also included items about diagnosed gastrointestinal diseases, heartburn frequency, and postprandial heaviness, indirectly assessing masticatory efficiency effects on digestive function.

Questionnaires were completed in a quiet setting with medical personnel available to clarify questions, but patients responded independently to minimize interviewer bias. Average completion time was 15-20 minutes. All questionnaires were checked for completeness and coded for subsequent electronic database entry.

Statistical analysis was performed using Statistica 12.0 (StatSoft Inc., USA). For each quantitative parameter, mean, standard deviation, standard error, minimum, and maximum values were calculated. Normality was tested using the Shapiro-Wilk test. For comparisons among four independent groups, one-way ANOVA with post-hoc Tukey test was used for normally distributed data; Kruskal-Wallis test with Bonferroni-corrected Mann-Whitney pairwise comparisons was used for non-normally distributed data. Qualitative characteristics were analyzed using Pearson's χ^2 test. Correlations between objective postural parameters and subjective patient assessments were evaluated using Spearman's rank correlation coefficient. Differences and correlations were considered statistically significant at $p < 0.05$. Interpretation emphasized the clinical significance of findings beyond statistical significance alone.

Results and Discussion

Comprehensive examination of 220 participants divided into four groups based on distal occlusion presence and orthodontic treatment timing yielded data enabling assessment of timely malocclusion correction effectiveness. The control group provided reference values for all parameters.

Cephalometric analysis revealed significant intergroup differences. In Group 1 (treated before age 18), parameters corresponded to control values. Group 2 (treated at 25-32) showed improved occlusal relationships, though 38.3% retained residual skeletal anomalies. Untreated Group 3 exhibited progressive deformities with all parameters significantly differing from controls.

Ultrasound assessment showed TMJ dysfunction in 73.3% of Group 3, 41.7% of Group 2, and 15.0% of Group 1, compared to 7.5% in controls. Electromyography demonstrated significantly higher resting muscle tone in untreated patients versus controls. Group 1 values were comparable to controls, with Group 2 intermediate.

Postural assessment confirmed close occlusion-spine relationships. Untreated patients exhibited forward head position (head tilt 48.6±4.2° vs 37.5±3.6° in controls), increased thoracic kyphosis (51.3±5.7° vs 41.8±4.9°), and compensatory lumbar lordosis (42.7±4.9° vs 33.9±4.1°). Group 1 showed no differences from controls. Group 2 demonstrated partial normalization. Stabilometry revealed stabilogram ellipse area 1.9 times larger in untreated patients than controls, indicating impaired balance.

Subjective symptom frequency is presented in **Figure 1**. The diagram demonstrates minimal symptom frequency in controls with progressive increases across groups. Regular headaches affected 12.5% of controls, 18.3% of Group 1, 41.7% of Group 2, and 68.3% of Group 3. Neck pain affected 10.0% of controls, 16.7% of Group 1, 55.0% of Group 2, and 81.7% of Group 3. TMJ clicking occurred in 5.0% of controls, 11.7% of Group 1, 36.7% of Group 2, and 70.0% of Group 3. Dental satisfaction was 92.5% in controls, 81.7% in Group 1, 56.7% in Group 2, and only 15.0% in Group 3. Morning facial puffiness was absent in controls but reported by 11.7% of Group 1, 25.0% of Group 2, and 51.7% of Group 3. Subjective skin quality (VAS 0-10) was rated 8.5±1.1 in controls, 7.8±1.2 in Group 1, 6.1±1.4 in Group 2, and 4.3±1.5 in Group 3.

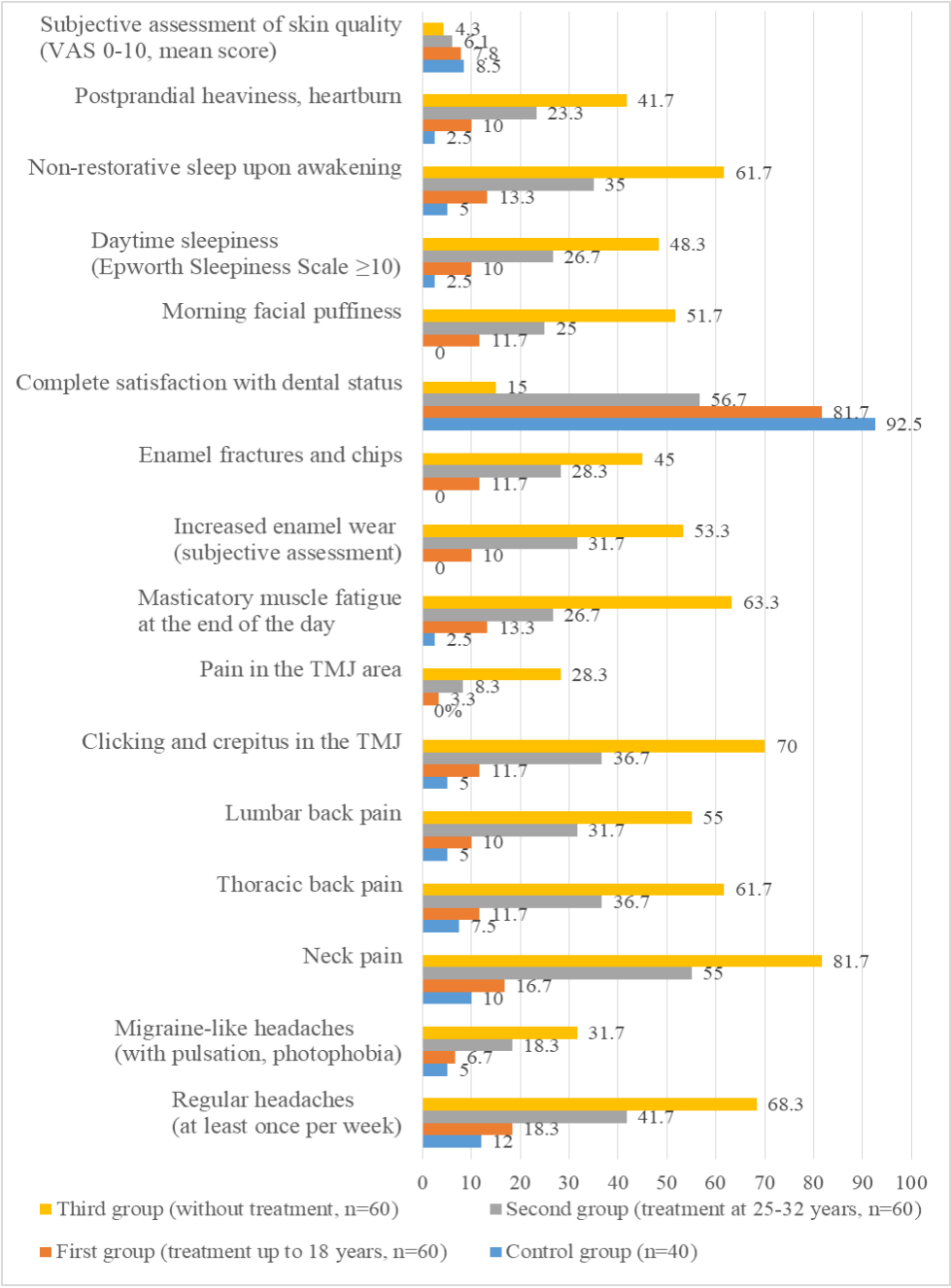


Figure 1. Frequency of Subjective Symptoms in Study Participants Depending on Distal Occlusion Presence and Orthodontic Treatment Timing (Percentage of Participants per Group)

Cephalometric parameters are presented in **Table 2**. The ANB angle was 2.2±0.8° in controls, 2.8±1.2° in Group 1, 4.1±1.4° in Group 2, and 6.3±1.6° in Group 3. Oropharyngeal airway space was minimal in untreated patients (212.4±41.2 mm² vs 312.5±38.6 mm² in controls). This measurement represents sagittal cross-sectional area; relative differences remain clinically significant. In Group 1, airway parameters did not differ from controls. Group 2 showed partial normalization.

Table 2. Comparative Analysis of Cephalometric Parameters in Study Participants Depending on Distal Occlusion Presence and Orthodontic Treatment Timing (M±SD)

Parameter	Control Group (n=40)	Group 1 (treatment before 18, n=60)	Group 2 (treatment at 25-32, n=60)	Group 3 (no treatment, n=60)	Significance p
ANB angle, degrees	2.2±0.8	2.8±1.2	4.1±1.4*	6.3±1.6*#	<0.001
Interincisal angle, degrees	132.6±5.8	128.4±6.3	124.7±7.1*	118.2±8.4*#	<0.001
Overbite depth, mm	2.4±0.7	3.2±1.1	4.3±1.3*	6.1±1.5*#	<0.001
Hyoid bone to vertebral plane distance, mm	10.2±1.8	11.3±2.1	13.8±2.4*	16.5±2.7*#	<0.001
Oropharyngeal airway space, mm²	312.5±38.6	284.6±42.3	251.8±38.7*	212.4±41.2*#	<0.001

Note: * - statistically significant difference from control group (p<0.05); # - statistically significant difference from Group 1 (p<0.05).

Postural status parameters are shown in **Table 3**. Head tilt angle reached 48.6±4.2° in Group 3 versus 37.5±3.6° in controls. Thoracic kyphosis and lumbar lordosis followed similar patterns. Group 1 values did not differ from controls. Group 2 occupied an intermediate position, significantly differing from both control and Group 1.

Table 3. Postural Status Parameters in Study Participants Depending on Distal Occlusion Presence and Orthodontic Treatment Timing (M±SD)

Parameter	Control Group (n=40)	Group 1 (treatment before 18, n=60)	Group 2 (treatment at 25-32, n=60)	Group 3 (no treatment, n=60)	Significance p
Head tilt angle, degrees	37.5±3.6	38.2±3.8	43.1±4.0*	48.6±4.2*#	<0.001
Thoracic kyphosis, degrees	41.8±4.9	42.5±5.1	46.8±5.4*	51.3±5.7*#	<0.001
Lumbar lordosis, degrees	33.9±4.1	34.6±4.3	38.2±4.6*	42.7±4.9*#	<0.001
Frontal plane center of pressure displacement, mm	2.4±1.5	3.2±1.8	5.4±2.1*	8.3±2.5*#	<0.001
Stabilogram ellipse area, mm²	118.6±38.4	126.4±42.7	178.5±51.3*	227.8±58.6*#	<0.001

Note: * - statistically significant difference from control group (p<0.05); # - statistically significant difference from Group 1 (p<0.05).

Electromyography results are presented in **Table 4**. Resting muscle tone was significantly higher in Group 3 versus controls. Group 1 values were comparable to controls. Group 2 showed intermediate values. The symmetry coefficient decreased progressively from controls (91.2±4.6%) to Group 3 (61.5±8.6%), indicating pronounced asymmetry in untreated patients.

Table 4. Electromyography Results of Masticatory Muscles in Study Participants Depending on Distal Occlusion Presence and Orthodontic Treatment Timing (M±SD)

Parameter	Control Group (n=40)	Group 1 (treatment before 18, n=60)	Group 2 (treatment at 25-32, n=60)	Group 3 (no treatment, n=60)	Significance p
Masseter muscle resting tone, μV	1.9±0.6	2.3±0.8	3.4±1.1*	4.8±1.3*#	<0.001
Temporalis muscle resting tone, μV	1.8±0.5	2.1±0.7	3.2±1.0*	4.5±1.2*#	<0.001
Maximum clenching amplitude, μV	198.4±30.2	184.6±32.5	156.8±28.7*	128.3±26.4*#	<0.001
Masticatory muscle symmetry coefficient, %	91.2±4.6	87.4±5.8	76.3±7.2*	61.5±8.6*#	<0.001

Note: * - statistically significant difference from control group (p<0.05); # - statistically significant difference from Group 1 (p<0.05).

Correlation analysis revealed significant associations between head tilt angle and headache frequency (r=0.64, p<0.001) and neck pain intensity (r=0.71, p<0.001). Stabilogram ellipse area negatively correlated with sleep quality and post-waking energy levels. These correlations were absent in controls but highly significant in distal occlusion groups, confirming formation of a stable pathological system.

This comprehensive study of 220 participants provided significant data for understanding the systemic consequences of dentofacial anomalies and evaluating the effectiveness of timely orthodontic correction. The results convincingly demonstrate that distal occlusion is not an isolated dental problem limited to aesthetic shortcomings but rather a systemic pathology involving various organs and body systems, forming stable pathological conditions that tend to progress with age in the absence of timely intervention [34-36].

The most important finding is evidence that orthodontic treatment performed during adolescence not only normalizes occlusal relationships but also prevents the development of secondary changes in the musculoskeletal system, temporomandibular joint, and muscular system [37, 38]. Group 1 patients showed no statistically significant differences from the control group in most objective and subjective parameters, indicating virtually complete recovery of dentofacial system function. The ANB angle was 2.8±1.2° in Group 1, not differing from control values of 2.2±0.8°, while in untreated patients this parameter reached 6.3±1.6°, corresponding to severe skeletal anomaly.

Analysis of airway status is fundamentally important. Patients with untreated distal occlusion had minimal oropharyngeal airway space (212.4±41.2 mm² vs 312.5±38.6 mm² in controls), creating objective prerequisites for sleep-disordered breathing and obstructive sleep apnea syndrome. The hyoid bone in these patients occupied a lower and more posterior position, a known risk factor for airway obstruction. In timely-treated Group 1 patients, these parameters did not differ from controls, while Group 2 patients treated in adulthood showed only partial normalization. These findings have important clinical significance, as chronic nocturnal hypoxia associated with respiratory disorders can lead to cardiovascular diseases, metabolic disturbances, and cognitive impairment [39-41].

Postural disturbances identified in patients with distal occlusion fully confirm the concept of cranio-postural syndrome, according to which the dentofacial system and musculoskeletal apparatus function as a single biomechanical system [42-44]. Untreated Group 3 patients exhibited a characteristic postural pattern: forward head position with increased head tilt angle to 48.6±4.2°, increased thoracic kyphosis to 51.3±5.7°, and compensatory lumbar lordosis to 42.7±4.9°. Group 1 patients treated in adolescence showed postural parameters not differing from controls, indicating complete compensation and absence of pathological motor stereotype fixation.

Most interesting from a pathogenetic perspective is the analysis of Group 2 patients who received orthodontic treatment at age 25-32. Despite achieving occlusal correction, these patients retained residual postural disturbances and muscle imbalance [45], though significantly less pronounced than in untreated patients. Their head tilt angle was 43.1±4.0°, significantly above control values but lower than in untreated patients. By age 25-32, the pathological postural stereotype has already become established at the level of the central nervous system and musculoskeletal apparatus. Even after eliminating the primary cause, muscle memory continues to reproduce the habitual movement pattern, underscoring the need for comprehensive rehabilitation including kinesiotherapy and osteopathic correction [46-48].

The clinical significance of treatment at age 25-32 is evident when comparing key outcomes with untreated

patients: headache frequency decreased from 68.3% to 41.7%, neck pain from 81.7% to 55.0%, TMJ clicking from 70.0% to 36.7%, and dental satisfaction increased from 15.0% to 56.7%. These substantial improvements justify orthodontic treatment even in adulthood, despite residual deficits. These systemic relationships are illustrated in **Figure 2**.

Subjective assessment results are particularly valuable, reflecting the real impact of pathology on quality of life. The clear deterioration gradient from controls to Group 3 demonstrates that distal occlusion significantly affects daily well-being. Notably, Group 3 patients rated their skin quality almost half as low as controls and complained significantly more often of morning facial puffiness. Chronic muscle tension in the neck and head region impairs venous outflow and lymphatic drainage, affecting facial soft tissue trophism and potentially accelerating age-related changes [49, 50]. The ultimate result of all described pathogenetic processes is reduced patient quality of life, manifested by multiple subjective symptoms: chronic pain of various localizations, sleep disturbances, daytime fatigue, aesthetic problems, and psychological discomfort [51, 52].

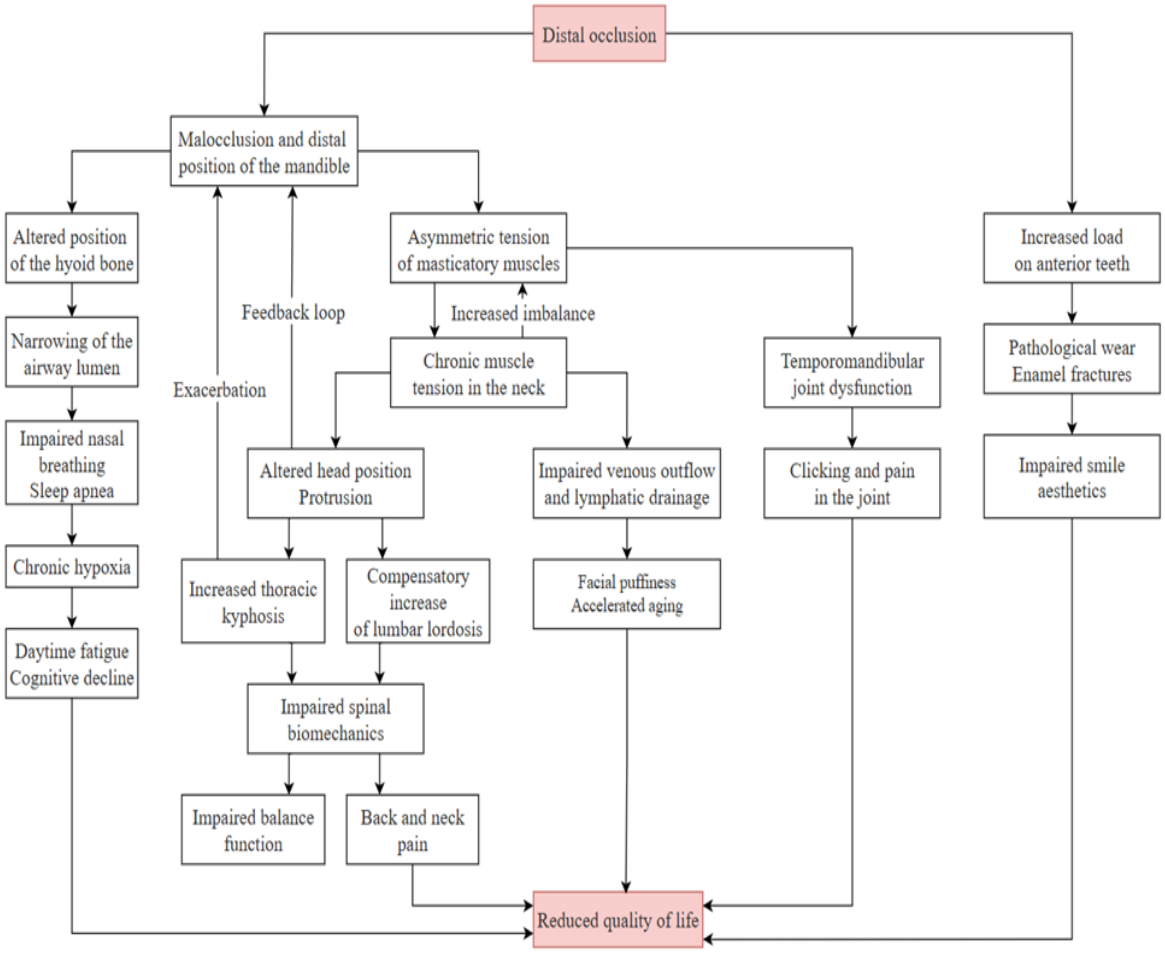


Figure 2. Pathogenetic Relationships and Formation of a Vicious Circle in Distal Occlusion

The diagram illustrates how the primary dentofacial anomaly triggers a cascade of pathological reactions. The central pathogenetic link is occlusal disturbance with distal mandibular position, leading to three main groups of consequences: altered hyoid bone position with airway narrowing, asymmetric masticatory muscle tension with musculoskeletal dysfunction, and altered cervical spine biomechanics. Each consequence initiates further pathological changes, forming an interconnected network [53, 54].

Critical feedback loops demonstrate vicious circle formation. Head protraction, developing as a compensatory reaction to respiratory disturbance, leads to greater distal mandibular displacement, exacerbating the initial occlusal problem [55]. Increased thoracic kyphosis from forward head position also contributes to fixing incorrect jaw position. Chronic neck muscle

tension both results from and maintains masticatory muscle imbalance. This self-sustaining pathological system progresses without timely intervention.

The positive correlation between head tilt angle and headache frequency (r=0.64) and neck pain intensity (r=0.71) confirms that postural disturbances have direct clinical significance. The negative correlation between stabilogram ellipse area and sleep quality indicates that balance impairment affects nocturnal rest quality.

Electromyographic data deserve special discussion. Increased resting tone of masseter and temporalis muscles in untreated patients indicates chronic tension maintaining pain syndrome and contributing to muscle-tonic disturbances. Reduced contraction amplitude during maximum clenching indicates functional insufficiency of masticatory muscles, negatively affecting chewing quality [56, 57]. In Group 1 patients, these parameters did not differ from controls, confirming the importance of timely treatment.

The significantly higher frequency of pathological wear, enamel fractures, and dental visits in untreated patients demonstrates that distal occlusion creates prerequisites for accelerated tooth destruction [58-60]. Uneven masticatory load distribution leads to overloading of anterior teeth and premature wear, increasing economic burden.

The trend toward increased postprandial heaviness and heartburn in untreated patients suggests that insufficient chewing due to occlusal disturbances may affect gastrointestinal function, requiring further study [61, 62].

Our results correspond well to current understanding of systemic effects of dentofacial anomalies. TMJ dysfunction frequency in untreated patients (73.3%) is consistent with literature data [63, 64]. Identified postural disturbances fully correspond to descriptions of cranio-postural syndrome, and positive effects of orthodontic treatment on postural parameters are confirmed by other researchers [65-68].

The practical significance lies in justifying timely orthodontic treatment not only from an aesthetic but also from a medical perspective. Untreated distal occlusion leads to stable pathological changes that progress with age and are difficult to correct even after eliminating the primary cause. Timely treatment in adolescence normalizes occlusion and prevents secondary changes, maintaining quality of life at the level of healthy individuals.

Study limitations include its cross-sectional design and retrospective assessment of initial status from medical records. Future research should include prospective observations from adolescence through long-term follow-up.

Conclusion

This comprehensive study of 220 participants convincingly demonstrated that distal occlusion is not an isolated dental defect but rather a systemic pathology. It triggers a cascade of pathological reactions involving the temporomandibular joint, masticatory muscles, airways, and musculoskeletal system. The obtained data confirmed the existence of a vicious circle in which dentofacial anomaly and postural disturbances mutually aggravate each other, forming a stable pathological stereotype that progresses with age.

Comparative analysis of the four participant groups revealed a clear pattern: the earlier orthodontic treatment was performed, the closer all studied parameters were to those of healthy individuals. Patients treated in adolescence showed no statistically significant differences from the control group in most objective and subjective parameters. Their head tilt angle was 38.2±3.8° versus 37.5±3.6° in controls. In untreated patients, it reached 48.6±4.2°, indicating pronounced head protraction. Oropharyngeal airway space in untreated patients was minimal at 212.4±41.2 mm² versus 312.5±38.6 mm² in controls, creating prerequisites for sleep-disordered breathing and chronic hypoxia.

Patients treated at age 25-32 showed intermediate results. They demonstrated significant improvement compared to untreated patients, with headache frequency reduced from 68.3% to 41.7% and neck pain from 81.7% to 55.0%. However, they retained residual postural disturbances and muscle imbalance. This indicates the need for comprehensive rehabilitation, including kinesiotherapy, in cases of late referral.

Subjective patient assessment revealed a clear quality of life deterioration gradient from the control group to untreated patients. While 92.5% of controls and 81.7% of Group 1 were completely satisfied with their dental status, this figure was only 15.0% in Group 3. Morning facial puffiness complaints were absent in controls but reported by 51.7% of untreated patients, confirming the impact of chronic muscle tension on tissue trophism.

Thus, timely orthodontic treatment in adolescence not only normalizes occlusion but also prevents the development of systemic disturbances, maintaining patients' quality of life at the level of healthy individuals. Treatment in adulthood, while not eliminating all consequences, provides significant improvement compared to no therapy and should be

considered an obligatory component of comprehensive rehabilitation with an interdisciplinary approach.

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Conflict of Interest: None

Financial Support: None

Ethics Statement: This study was conducted in accordance with the Declaration of Helsinki. All participants provided informed consent before enrollment. The study protocol was approved by the Ethics Committee of the Dental Clinics of Grozny, Chechen Republic. Patient data were anonymized and processed in compliance with confidentiality requirements.

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