Original Research

Therapeutic challenges in temporomandibular disorders

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Abstract

Background and aims. This study aimed at evaluating the etiology and treatment challenges of temporomandibular disorders (TMDs).

Methods. 160 subjects with TMDs, 38 males (23.8%) and 122 females (76.3%) were studied. A personalized coefficient was designated, which included the resolution of the main symptom, correction of secondary symptoms, patient collaboration (emotional parameter), treatment duration, and cost.

Results. The most frequent cause for consultation was muscle impairment (42.5%), or limitation of mouth opening, followed by joint impairment (23.1%). Muscle pain was noticed, particularly in the masseter (57.5%) and lateral pterygoid muscles (51.9%). Tooth pain or gingival retraction was frequently associated with tooth wear (48.1%) and dental abfraction (31.3%). Remote symptomatology was dominated by otologic symptomatology. Iatrogenic etiology was highest (69.4%), followed by untreated missing teeth (66.9%). Treatment options included muscle relaxation, occlusal balancing (equilibration), kinesitherapy, medication, and swallowing re-education. Most patients benefited from four to seven different types of therapy, which resulted in a higher cost and a longer and more uncomfortable treatment. The primary symptom was relieved in 82.3% of cases, with recurrence occurring in 15.7%.

Conclusion. The treatment of temporomandibular joint dysfunction is time-consuming, demanding, and intricate. Most patients required four to seven different types of therapy, which increased the expense, treatment duration, and suffering.

Keywords: temporomandibular joint disorder, myalgia, jaw, pain, occlusion

Introduction

Temporomandibular disorders (TMD) related symptoms could refer to temporomandibular joint (TMJ) discomfort, masticatory muscles impairments, difficulties in opening the jaw, and TMJ noises [1]. TMDs can be related to ear symptoms, which are caused by a dysfunction in the masticatory system [2]. Patients suffering from myofascial pain are more anxious and depressed than those suffering from other types of TMD [3]. Individuals with TMD often report discomfort regularly as a symptom, craniofacial pain being the most common symptom for which patients seek therapy [4].

The absence of fundamental knowledge regarding TMD may delay diagnosis, impede therapy, and raise the risk of worsening the illness [5].

Due to the complexity of the disease, the diagnostic criteria for temporomandibular disorders have evolved over time, the clinical examination includes a pain history questionnaire along with methods for evaluating psychological and behavioral aspects that may contribute to the development and maintenance of TMD, enabling a complete review of the

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pathology [6]. To make a reliable diagnostic of TMD, it is necessary to apply diagnostic tools that require a clinical assessment [7]. Inspection and palpation in person by a practitioner combined with surveys are the optimal option for assessing TMD [8]. Imaging may serve as a significant complement in the diagnosis of TMD in a subset of patients, even though clinical evaluation is regarded as the most crucial approach; owing to the intricacy of the pathogenesis, the identification and therapy of TMD continue to be a problem in which agreement in many areas is still lacking [9]. Although artificial intelligence algorithms designed for identifying TMDs may bring extra medical knowledge to boost diagnoses performance, they may not be as reliable as human experts [10]; it is essential to emphasize that they bring alongside them a significant risk of bias and that will not be able to take the position of trained medical professionals in making a clinical diagnosis.

TMDs might result in malocclusion owing of the functional damage they induce. If malocclusions are caused by temporomandibular dysfunction, it is crucial to perform an accurate diagnostic test and not neglect the underlying condition [11]. According to systematic reviews, the role of occlusion as a key factor in the development of TMDs is low, TMDs, on the other hand, can cause subsequent modifications in dental occlusion [12].

Intrinsic disturbance, which is mostly caused by joint disc dislocation, is the most typical cause of TMD, being a leading source of patient pain and impairment [13]. A study examined the relationship between neck impairment, jaw functionality, and muscle discomfort in patients with and without chronic TMD and that found elevated degrees of muscular discomfort in the upper trapezius and temporalis muscles were associated with high levels of dysfunction in the jaw and neck [14].

Due to the fact that prevention is simpler than treatment, it has been shown that Vitamin D may be a harmless, straightforward, and possibly advantageous strategy to avoid TMDs [15].

The treatment of patients with TMD is complex, and includes, an occlusal splint as a non-invasive treatment option [16,17], teledentistry techniques [18], low-level laser therapy, transcutaneous electrical nerve stimulation, therapeutic ultrasound [19], acupuncture, laser therapy, and physiotherapy [20], dental restoration approaches [21], exercise, manual therapy, patient education [22], nonsteroidal anti-inflammatory drugs [23] and intra-articular administration of hyaluronic acid [24]. There is still a lack of clarity on the most effective method of therapy for the therapy of TMDs of muscular etiology, however, the most appropriate therapy being physical treatment, followed by psychological intervention, intramuscular injections of anesthetic substances, and occlusal appliances [25]. Botulinum toxin at low dosages is beneficial in the treatment of refractory myofascial pain caused by temporomandibular disorders [26]. There is conflicting information about the effectiveness of psychological therapy on painful temporomandibular disorders [27]. Improvement in pain, maximum mouth opening, mandible functional limitations are among the most successful results of TMD therapy [28].

The aim of this study was to assess patient information and findings on TMD signs and symptoms, as well as to examine etiological factors and treatment strategies.

Methods

A retrospective, analytical, and observational study was performed. The research was conducted over two years, between 2020 - 2022.

One hundred and sixty consecutive subjects, who visited our temporomandibular disorder clinic, were selected. Patients who were referred to our clinic by other dentists or health care professionals were recruited from those seeking treatment from a TMD expert with over 20 years of experience.

The inclusion criteria were the presence of a sign or symptom of temporomandibular disorder: muscle or joint disorder, TMD related headache, neck pain related to sternocleidomastoid and trapezius muscle, or remote symptomatology (ear, eye, throat). The exclusion criteria were the presence of maxillofacial trauma, tumors, or other diseases of the muscles or joints non-TMD related (e.g., rheumatoid polyarthritis, myositis, general diseases that made communication with the patient difficult or impossible (epilepsy, neurological or psychiatric disorders, rheumatologic disorders), patients following orthodontic or extensive dental treatments, and patients unwilling to participate in the study. TMD patients with considerable levels of depression and somatization, as well as a high incidence of pain-related impairment in social activities, as defined by the RDC/TMD axis II criteria for psychosocial symptoms, were excluded [29,30] .

The Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) of the International TMD Consortium Recommendations were followed for the clinical diagnosis of the disease [31].

The examination and diagnosis were performed by one dental professional with over 20 years of experience in TMD therapy, and the treatment outcome was evaluated by the same physician (S.B.). The patient information and findings related to TMD signs and symptoms were evaluated. The static dental relationships were examined, according to Angle's class. The static and functional occlusion (maximum intercuspation, centric relation occlusion, and anterior guidance) were evaluated. The reported pain using a ten-point visual analog scale was

recorded (VAS) [32]. An analysis of etiological factors and therapeutic approaches was performed.

To assess the overall method of treatment of the case, a personalized coefficient was assigned, ranging between 0 (complete failure) and 10 (total resolution). The global coefficient referred to the resolution of the main symptom, the resolution of secondary symptoms, patient cooperation (emotional variable), intervention duration, and treatment cost.

IBM SPSS Statistics 22 was used to conduct statistical analysis (Armonk, NY, USA). The Shapiro-Wilk test and Q-Q plots were used to assess the normality of the variable sets. Mean, median, standard deviation (SD), and minimum and maximum values were used to characterize quantitative variables. Also, correlation coefficients were performed between multiple variables: muscle symptoms, joint symptoms, periodontal symptoms, and remote symptoms, results from anterior bite plane on muscle pain, remote pain, muscle pain, joint noises, kinematic disorders, remote symptoms, joint pain, periodontal symptoms, kinesiotherapy, and medication. The significance threshold was established at 0.05 for the studied hypotheses.

Results

A number of 160 subjects were studied: 38 males (23.8%) and 122 females (76.3%). The most affected age group was 20-29 years, followed by 30-39 years; regardless of gender, there was the same level of involvement by age group (Supplementary Table S1).

The most likely cause for consultation was related to the muscles (pain or limitation of mouth opening), followed by the joint (pain or joint noises), while the other impairments were less common, most likely because they did not interfere with the functionality of the dental-maxillary apparatus to the same extent (Table I).

The severity of muscular pain was graded on a scale of 0 to 10. One hundred and ten patients reported muscle pain, the most stated pain level was six (mean =5.64, SD=1.84, n=110). In male patients, the majority felt pain at the level of the threshold of four, with the distribution being asymmetric, either extremely intensely or not at all (mean =5.25, SD=1.97, n=20, minimum=2, maximum=9). Of respondents, the majority reported more pain than males, level six, with a balanced and symmetrical distribution of patients in all pain categories (mean=5.7, SD=1.81, n=90, minimum=2, maximum=9).

The presence of pain was observed, particularly at the level of the masseter and lateral pterygoid muscles (Supplementary Table S2).

By examining the number of painful symptoms at the muscle level, it was shown that most patients had an average of two, three, or even four affected muscles, whereas, at the joint level, most subjects had two or more symptoms (mean =1.6, SD=1.11, n=160). Abrasion and dental abfraction were often encountered by tooth pain or gingival retraction. Dental and periodontal problems were encountered in 96 cases (mean =2.5, SD=1.57, n=96) (Supplementary Table S3).

Otologic symptomatology ranked highest in terms of distanced symptomatology. This group included ear pain, the sensation of blocked ears, and transitory hearing disorders. Neurological disorders such as headache, dizziness, equilibrium abnormalities, and changes in skin sensitivity came in the second position. Pseudo-sinusitis pains induced by masseter muscle spasm, followed by eye injury manifested as retroorbital pain, lacrimation, and photophobia, all of which were associated with dysfunction of the temporal, head, and neck muscles were also encountered (mean =2.1, SD=1.07, n=76).

The analysis of etiological factors revealed that iatrogenic causes came in first, followed by untreated missing teeth (mean =0.7, SD=0.65, n=160). Fixed prostheses were the most frequent cause of iatrogenic complications, followed by incomplete orthodontic procedures and inappropriate dental restorations. Improper surgical procedures included either vicious jaw consolidation following fractures or incorrect Spix spine placement, resulting in pterygoid-mandibular ligament injury and reflex trismus. Other important identified factors included dysfunctional swallowing and dental-maxillary anomalies (Table II). In terms of the number of identified etiological factors, most patients had four (mean =3.9, SD=1.84, n=160).

Table I. The primary symptom that influenced clinic appointments.

Main symptom	Frequency (n)	Percent (%)	Males (n; %)	Females (n; %)
Muscle impairment	68	42.5	13;34.2	55; 45.1
Joint impairment	37	23.1	10; 26.3	27; 22.1
Jaw kinematic disorders	28	17.5	7; 18.4	21; 17.2
Remote disorders from the dental maxillary apparatus	11	6.9	1; 2.6	10; 8.2
Dental and periodontal alterations	16	10.0	7; 18.4	9; 7.3
Total	160	100	38; 100	122; 100

Table II. Analysis of etiological factors.

Factor	Frequency (n)	Percent (%)
Trauma	9	5.6
Malocclusion	64	40
Non-treated dental decays	22	13.8
Non treated edentulism	107	66.9
Third molar	30	18.8
Periodontitis	10	6.3
Parafunction	44	27.5
Bruxism	37	23.1
Iatrogenic	111	69.4
Removable partial denture	9	5.6
Fixed prosthesis	52	32.5
Orthodontic treatment	32	20
Direct tooth restoration	19	11.9
Surgical treatment	3	1.9
Swallowing dysfunction	80	50
Abnormal posture	26	16.3
Neurological disorder	6	3.8
Intracapsular joint disorder	7	4.4
Emotional disorders	28	17.5
General condition disorders	33	20.6

According to Angle's class, there were 112 cases in class I, 15 in class II subdivision 1, 20 in class II subdivision 2, 1 in class III, 2 complete edentulous, and 10 indeterminate class.

A considerable number of patients had an absence of bilateral canine contacts. Canine contacts were observed in subjects from class II/2, the dysfunction was most likely caused by alterations in the vertical dimension of occlusion (Table III).

There was a considerable correlation between muscular and remote symptoms, which were directly proportional, as well as between muscular and dental-periodontal symptoms, which were inversely proportional (Table IV).

The treatment modalities included muscle relaxation, occlusal balancing, kinesitherapy, medication, and swallowing re-education (Supplementary Table S4). Only a total of 140 subjects agreed to undergo treatment. In almost all cases, selective grinding was required, and prosthetic therapy was the next step. Most patients benefitted from two treatments in the setting of occlusal balance (mean =2.1, SD=0.72, n=140).

Most patients who received pharmacological therapy benefited from a combination of two medications. Most of the patients benefitted from a treatment inventory of five procedures. Joint sounds and kinematic disturbances were the most satisfying effects of kinesiotherapy, with the fewest recurrences, which was also effective in relieving joint pain, but not in relieving muscular discomfort (Supplementary Table S5). The results of kinesiotherapy on limited jaw opening, on the other hand, were inconclusive.

The medication provided the best effect for joint discomfort, mouth opening restriction, and muscle pain. It made no difference to joint noises or kinematic deficits. Only half of the patients were able to successfully re-educate their abnormal swallowing. The major symptom was alleviated in more than 80% of cases, indicating treatment effectiveness. The subsequent symptoms from the original one for which the patient sought therapy ranged from one to nine. It was possible to cure between two and five secondary symptoms, which could be regarded favorably (mean =3.4, SD=1.79, n=140). In terms of unresolved symptoms, the majority were zero, with just a small proportion persisting (one symptom: 34.4%, respectively four symptoms: 2.9%) (mean =1.0, SD=1.07, n=140).

The general acceptance of the solution to the issue, according to the personalized score was situated in most cases between 9 - 10. There was also a subset of individuals whose therapy did not go as planned. In general, the recommended treatment strategy achieved

Table III. Canine contacts according to Angle's class.

	Angle class I	Angle class II/1	Angle class II/2	Angle class III
Bilateral canine contacts	61	8	12	1
Unilateral canine contacts	20	1	5	0
No canine contacts	31	6	3	0
Total	112	15	20	1

Table IV. Symptoms correlations.

	Muscle symptoms (r, p-value)	Joint symptoms	Periodontal symptoms	Remote symptoms
Muscle symptoms	1, -	0.044,0.578	-0.210**, 0.008	0.442**, 0.0001
Joint symptoms	0.044, 0.578	1, -	-0.148, 0.062	-0.106, 0.183
Periodontal symptoms	-0.210**, 0.008	-0.148, 0.062	1, -	-0.074, 0.353
Remote symptoms	0.442**, 0.0001	-0.106, 0.183	-0.074, 0.353	1, -

r-correlation coefficient

effectiveness (mean =8.0, SD=2.64, n=140). The therapy was unsuccessful or was followed by relapse in 15.7% of cases.

The muscle group dysfunction based on interference type was analyzed. The temporalis muscle, masseter, and lateral pterygoid were most affected by passive lateral interferences. The medial pterygoid muscle was influenced essentially similarly by all types of changes, with the greatest value observed for passive lateral interference and the lowest for anterior guidance modifications. The descending muscles were mostly affected by the changes in the vertical dimension of occlusion, whereas neck and spine muscles by vertical dimension of occlusion changes and passive propulsive interferences (Table V).

The most harmful situations were those with a loss of the unilateral antagonistic canine, which caused alterations in all muscles. Regarding the loss of canine participation in lateral guiding, it was found that the greatest injury occurred in the event of unilateral canine functional absence. The anterior bite plane treatment eliminated both the muscular discomfort and the remote symptoms at the same time (Table VI).

Table V. Assessment of muscle group impairment depending on the type of interference.

Interference	Temporalis muscle (%)	Masseter muscle (%)	Medial pterygoid muscle (%)	Lateral pterygoid muscle (%)	Descending muscles (%)	Neck and spine muscles (%)	Number of cases (n)
In maximum intercuspation	39.3	58.5	23.7	52.6	17	23.7	135
Alteration of the lateral guidance	38.1	57.1	27.6	55.2	15.2	23.8	105
Working interference in lateral guidance	36.1	60.2	24.1	53.7	16.7	23.1	108
Non-working interference in lateral guidance	80	80	40	60	20	40	5
Alteration of the anterior guidance	37.9	48.3	20.7	44.8	24.1	27.6	29
Working interference in lateral guidance	45.1	60.8	21.6	54.9	19.6	23.5	51
Non-working interference in lateral guidance	59.4	68.8	37.5	56.3	9.4	56.3	32
Absence of opposing canine contacts	37.5	62.5	25.5	58.3	41.7	45.8	24

Table VI. Correlations between symptoms and treatment types.

Variables correlated	Correlation coefficient	p-value
Muscle symptoms – periodontal symptoms	-0.210	0.008
Muscle symptoms –remote symptoms	0.442	0.0001
Results anterior bite plane muscle pain – results anterior bite plane joint pain	0.314	0.0001
Results anterior bite plane muscle pain – results from anterior bite plane remote pain	0.459	0.0001
Results anterior bite plane muscle pain – muscle pain symptoms	0.553	0.0001
Results from anterior bite plane joint noises – results from a anterior bite plane kinematic disorder	0.349	0.0001
Results from anterior bite plane joint noises – results from remote symptoms	-0.187	0.027
Results anterior bite plane remote symptoms – muscle pain symptoms	0.267	0.001
Results anterior bite plane remote symptoms – results from anterior bite plane kinematic disorders	-0.187	0.027
Results anterior bite plane muscle pain – pain joint symptoms	0.267	0.001
Results anterior bite plane joint pain – pain joint symptoms	0.303	0.0001
Results anterior bite plane remote symptoms – pain joint symptoms	0.528	0.0001
Results anterior bite plane kinematic disorders – pain joint symptoms	-0.207	0.014
Results anterior bite plane muscle pain – pain periodontal symptoms	-0.251	0.003
Results anterior bite plane muscle pain – pain remote symptoms	0.264	0.002
Results anterior bite plane remote symptoms – pain joint symptoms	0.166	0.050
Results of kinesitherapy muscle pain – results from kinesitherapy joint pain	0.175	0.038
Results of kinesitherapy joint pain – results from kinesitherapy kinematic disorders	0.222	0.008
Results kinesitherapy joint noises – results from kinesitherapy kinematic disorders	0.681	0.0001

Table VI. Correlations between symptoms and treatment types (continuation).

Variables correlated	Correlation coefficient	p-value
Results of kinesitherapy joint pain – results from kinesitherapy remote pain	-0.198	0.019
Results kinesitherapy joint pain – symptoms joint pain	0.189	0.026
Results kinesitherapy joint noises – symptoms joint pain	0.299	0.0001
Results kinesitherapy remote symptoms – symptoms of joint pain	-0.179	0.034
Results kinesitherapy kinematic disorders – symptoms of joint pain	0.269	0.001
Results of medication muscle pain – results from medication joint pain	0.460	0.0001
Results of medication muscle pain – results from medication joint noises	-0.534	0.0001
Results medication muscle pain – results from medication kinematic disorders	-0.482	0.0001
Results medication muscle pain – symptoms muscle pain	0.436	0.0001
Results of medication joint pain – results from medication joint noises	-0.280	0.001
Results medication joint pain – results from medication kinematic disorders	-0.224	0.008
Results medication joint noises – results from medication kinematic disorders	0.706	0.0001
Results medication joint noises – symptoms muscle pain	-0.297	0.0001
Results medication kinematic disorders – symptoms of muscle pain	-0.267	0.001
Results medication joint pain – symptoms joint pain	0.261	0.002
Results medication joint noises – symptoms joint pain	-0.307	0.0001
Results medication kinematic disorders – symptoms of joint pain	-0.189	0.025
Results medication joint noises – remote pain symptoms	-0.173	0.041
Results medication kinematic disorders – symptoms of joint pain	-0.200	0.018

Discussion

In our study we have shown that temporomandibular disorders are a condition that primarily affected women (76.3%). Regardless of gender, the most affected age group was between 20 and 29 years old. The female prevalence was higher, which is consistent with the results shown by Bueno et al, who revealed that in every RDC/TMD clinical entity, women had a greater incidence of TMD than males [33].

It was not unexpected that in this study otologic symptomatology was the most common symptomatology at a distance, given that spasms from the masseter and lateral pterygoid muscles trigger pain in the ear. Salvetti et al. reviewed the literature and showed that the incidence of ear symptoms in the general population ranged from 10% to 31%, but TMD patients had a frequency of up to 85% [34].

Most patients had four indicated etiological variables. These data corroborate the dysfunctional syndrome's multifaceted character. In the context of occlusal balance, most patients benefited from two treatments, supporting the idea that dental harmony is seldom obtained just by selective grinding.

Given that one of the premises upon which we started was the fineness of canine periodontal proprioception and the way it guided mandibular movements, it was investigated whether there are bilateral antagonized canine reports that contribute to the stability of the mandible in the position of mouth closure.

Occlusal modifications employing the biting plate-induced occlusal posture have been previously documented for the treatment of temporomandibular disorders [35]. In this study, the outcomes of the anterior bite plane were the most successful, with the fewest recurrences of muscle pain and mouth opening limitations. On the other hand, the findings regarding joint noises and kinematic abnormalities were inconclusive. The anterior bite plane technique eliminated painful muscular symptoms in addition to the initial number of symptoms, proving its efficiency over all painful muscular symptoms. The results of the remote symptomatology plan correlated with joint pain, suggesting that joint pain had a muscle component. Physical therapy addressed both mandibular kinematic issues and joint sounds. Given the wide range of techniques and factors utilized for the accuracy of kinematic parameters for the assessment of temporomandibular joint function and dysfunction, further evidence is required [36].

One of the most frequently prescribed therapeutic approaches for treating TMDs are nonsteroidal anti-inflammatory drugs and relaxants, while opioids, anxiolytics, and antidepressants are recommended less frequently [37]. In the current study, both muscle and joint pain were treated with medication, giving more support for the muscular component of joint pain. The correlation between the medication's effects on joint sounds and kinematic anomalies and its efficacy was very weak. Nonsteroidal anti-inflammatory medicines (44.3%), muscle relaxants (37.9%), analgesics (25%), and anesthetic infiltrations (9.3%) were used to treat patients, with most patients benefitting from a combination of two treatments. The medical therapy influenced both types of pain and limited mouth opening, showing once again that muscle

relaxation and pain elimination, and hence muscular spasm, lead to the alleviation of uncomfortable functional symptoms. The medication did not affect joint noises and had little influence on kinematic disorders, most likely mainly those caused by muscle fatigue.

There was no correlation between pain medication and kinematic difficulties or joint sounds, indicating that these conditions did not seem to have a muscle origin. The masseter and lateral pterygoid muscles were most often affected by muscular deterioration in relapsed individuals. Dento-maxillary abnormalities that were the most challenging to manage and cure in adulthood were often associated with relapses of joint noises and muscle discomfort. Relationships between recurrence and untreated edentulism, uncorrected dysphagia, and emotional and general condition abnormalities were shown to be significant. It has been shown that changes in posteroanterior cephalometric measures are associated with unilateral TMDs [38].

The fact that most patients had two, three, or four damaged muscles lends credence to the notion of muscular synergy and tight coordination between the dental-maxillary apparatus components. Impairment to a single muscle happened less often, but was still more frequent than damage to all muscles, indicating that depletion of the body's functional reserves was infrequent. There is a relationship between temporomandibular disorders and cervical posture [39].

Most patients (42.5%) had clear symptomatology of a dysfunctional syndrome with a muscle component, with muscular pain being the most prevalent. Articular symptomatology came in second having 32.1%, with clicking-type joint sounds being the most important signs. Dental and periodontal symptoms (10%) and remote ones (6.9%) did not have a reasonable account. This result could be explained by the fact that these symptoms did not cause a significant impairment of the dental-maxillary apparatus functions (in comparison to pain or limitations in mouth opening), or by the fact that not all patients with this type of symptomatology were diagnosed and referred to a specialist.

The method of assessing the muscles and the temporomandibular joint allowed for the differentiation of distinct types of pain from the beginning, allowing for a differential diagnosis between muscle and joint pain.

When rating pain severity on a scale of 0 to 10, no significant variations were detected based on gender, with most patients reporting six or above. The small number of patients with extremely high pain levels indicated that because of the emphasis they place on this symptom and the impediment it causes, patients seek consultation more rapidly.

The masseter muscle (57.5%) and the lateral pterygoid muscle (51.9%) were the muscles mainly impacted by discomfort. The lateral pterygoid muscle, sometimes known as the "dysfunction muscle", is involved in all mandibular movements. The masseter muscle, contrary to popular belief, has a role in bruxism and parafunction. The temporal muscle (41.3%) was the second most injured muscle. The relationship of the masseter, temporal, and lateral pterygoid muscles supports the idea of muscle synergy, as their insertions on the pre-discal disc generate a couple of forces (the tensor apparatus). Spasms in one will produce abnormal contractions in the other two. The relevance of the lateral pterygoid muscle in the development of TMD is connected to the beneficial impact of botulinum toxin injection of its effectiveness in treating TMD [40].

Without previous muscle relaxation, an occlusal diagnosis could not be established. This assertion is based on clinical findings in which a considerable number of dysfunctional persons lacked apparent functional occlusion problems and other identifying characteristics. The anterior bite plane (65%) was primarily responsible for muscle relaxation. The simple technical execution, a straightforward adjustment in the oral cavity, and fast results achieved to make this interocclusal device suitable to be used by practitioners. The anterior bite plane technique was effective in terms of muscle pain and oral cavity opening limitations. The favorable outcomes on pain initially categorized as articular illustrate the close functional connection between muscles and joints. Muscle relaxation allowed the articular components to realign, resulting in the absence of discomfort caused by retro-discal compression. The outcomes for joint noises (15.7% success) and kinematics disorders (12.9% success) indicate that in the case of an internal articular disturbance, muscular relaxation cannot identify a rearrangement of the articular elements and that another resolution and diagnostic position must be sought. As a result, this device can distinguish between functional muscle-joint impairment and an organic one.

The muscle-determined position, chosen as a therapeutic position following muscular relaxation, is more backward than the patient's maximal intercuspation position and anterior to the centric relation position. The muscle comfort relation overlaps Okeson's stable musculoskeletal relationship position, which is translated at the joint level by the absence of organic internal joint disturbances, superior placement of the condyle in the glenoid cavity, and not by a retruded, forced posture [41].

The occlusal adjustments performed in this position resulted in the patient feeling considerable comfort from the first session. Selective grinding (93.6%), prosthetic treatments (53.6%), dental reconstructions (37.1%), surgical treatments (dental extraction, 17.1%), and orthodontic treatments (7.9%) were the most common occlusal balancing procedures. Most patients benefitted from two occlusal harmonizing interventions.

In terms of occlusal analysis, it was found that the most frequent interferences were those from the

intercuspation position, while the most damaging to the muscles were those from the laterality position on the passive side, causing injury to nearly all muscle groups. Nevertheless, the propulsion passive side interferences were more likely to induce internal articular injury. Kinesiotherapy was recommended for more than half of the patients studied (50.7%) and showed effects, particularly for joint noises (32.1%) and kinematics problems (28.6%). There were fewer significant results on muscle and joint pain. This type of therapy is advised as adjunctive therapy in temporomandibular dysfunction with an internal articular disturbance component when the chosen reference position is different.

Swallowing re-education was recommended in 45% of patients, necessitating the assistance of a specialist who could follow the progress of the re-education. Along with the above-mentioned therapies, photobiomodulation is a useful supplement for the treatment of temporomandibular disorders since it is less invasive, and has no adverse effects [42].

In addition to occlusal factors, we also considered patients without behavioral factors (grinding, clenching, and abnormal head posture), social factors (could affect perception and influence the learned response to pain), emotional factors (depression and anxiety), and cognitive factors (lack of intelligence) (negative thoughts and attitudes which can make resolution of the illness more difficult). Also, the management of the disease was evaluated, with iatrogenicity playing a major role. The effective therapy of temporomandibular disorders is contingent on the identification and operation of predictors. In certain cases, iatrogenic injuries may serve as both starting and predisposing variables [43].

In addition to clinical examination, axiography is the least intrusive tool for evaluating temporomandibular joint dysfunction, since it does not irradiate the patient, and provides functional information regarding TMJ function [44].

Since the identification of TMD is mostly dependent on the patient's medical history and physical investigation results, [45] we determined the correlation between symptoms and treatment types because it is essential to know how much and what treatments were helpful based on symptoms and diagnosis.

Limitations and strengths

Due to the vast array of indications and symptoms, identifying the etiological component causing the dysfunction is very challenging from a clinical standpoint. Multiple therapeutic methods were accessible due to the diversity of the symptoms. It is difficult to choose which therapy to begin first. It is tough to decide which of the several therapy choices is the most effective. If we knew which treatment is most helpful at the onset of temporomandibular dysfunction, we could limit the amount of therapy sessions and choose fewer therapies. The study's strength stems from the large number of patients treated and the fact that all procedures, from examination to therapeutic maneuvers, were performed by a single operator, eliminating bias and supplementary confounding variables.

Implications for future research

Future studies should enhance digital examination of the occlusion, as well as the objective evaluation of the occlusion using methods such as T-Scan or Modjaw, a virtual scanning tool of the occlusion which is not operator-dependent. Studies that use magnetic resonance or axiography as methods of objective assessment of the joint and an objective examination of the occlusion may be pursued in the future.

Electromyography may be used to objectively study muscles, and modern treatments like arthrocentesis and botulinum toxin could be employed to broaden the therapeutic spectrum.

Conclusions

This study shows that the management of temporomandibular joint dysfunction is lengthy, costly, and complex. The majority of patients required between four and seven different types of therapy, resulting in an increase in cost, treatment duration, and discomfort. This research intends to raise the awareness that iatrogenicity in dental practice is an essential issue to consider, as it acts as a warning signal to professionals about the possible repercussions of the onset of temporomandibular disorders.

Significant effort in identifying the TMD condition via consultation with a number of medical experts is required. Multiple dental and general medical professions should collaborate on the evolution and therapy management. Training a physiotherapist who primarily focuses on TMJ disorders is vital. It is definitely more favorable and less expensive to prevent this condition as soon as possible.

Given the intricacy of the treatment, the complex etiology, and the various potential sources of failure, this condition should be managed with a holistic approach that targets both its causes and symptoms.

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Supplementary material

Supplementary Table S1. Distribution according to age.
Supplementary Table S2. Examination of the pain existence in different masticatory muscles (n=160 subjects).
Supplementary Table S3. Assessment of muscle, temporomandibular joint, dental and periodontal symptoms.
Supplementary Table S4. Assessment of therapeutic approaches.
Supplementary Table S5. Treatment results.

Informed consent statement

Informed consent was obtained from all subjects involved in the study. Written permission for the use of anonymous data in observational studies was provided by the patients enrolled in the study.

Supplementary Table S1. Distribution according to age.

Age categories	Frequency (n)	Percent (%)	Males (n; %)	Females (n; %)
<20 years	17	10.6	4;10.5	13; 10.7
20-29 years	74	46.3	12; 31.6	62; 50.8
30-39 years	32	20.0	8; 21.1	24; 19.7
40-49 years	13	8.1	6; 15.8	7; 5.7
50-59 years	16	10.0	4; 10.5	12; 9.8
>60 years	8	5.0	4; 10.5	4; 3.3
Total	160	100	38; 100	122; 100

Supplementary Table S2. Examination of the pain existence in different masticatory muscles (n=160 subjects).

Muscle	Pain present (n)	Percent (%)
Temporalis	66	41.3
Masseter	92	57.5
Medial pterygoid	41	25.6
Lateral pterygoid	83	51.9
Depressors muscles	28	17.5
Muscles in the neck and spine	43	26.9

Supplementary Table S3. Assessment of muscle, temporomandibular joint, dental and periodontal symptoms.

Symptomatology	Frequency (n)	Percent (%)
Muscle		
Muscular jaw movement limitation	29	18.1
Muscle hypertrophy	35	21.9
Muscle pain	111	69.4
Temporomandibular joint		
Joint pain	50	31.3
Joint noises - clicking	80	50
Joint noises - crepitus	10	6.3
Signs of disc displacement with reduction	32	20
Signs of disc displacement without reduction	21	13.1
Ligament laxity	9	5.6
Dental and periodontal		
Pain	27	16.9
Wear	77	48.1
Abfraction	50	31.3
Gingival inflammation	21	17.5
Gingival retraction	31	19.4
Tooth migration	17	10.6
Tooth mobility	12	7.5
Remote symptomatology	76	47.5

Supplementary Table S4. Assessment of therapeutic approaches.

Treatment type	Frequency (n)	Percent (%)
Muscle treatment		
Muscle active exercise	30	21.4
Relaxing techniques	19	13.6
Anterior bite plane	91	65
Occlusal equilibration		
Selective grinding	131	93.5
Direct restorations	52	37.1
Prosthodontics	75	53.6
Orthodontics	11	7.9
Surgery	24	17.1
Kinesitherapy	71	50.7
Medication		
Anti-inflammatory drugs	62	44.3
Pain relievers	35	25
Muscle relaxants	53	37.9
Anesthetic infiltrations	13	9.3
Swallowing re-education	63	45

Supplementary Table S5. Treatment results.

Results of anterior bite plane	Frequency (n)	Percent (%)
Results on muscle pain		
0 – no treatment	47	33.6
1 – a positive outcome	92	65.7
2 – an absence of a result	1	0.7
Results on joint pain		
0 – no treatment	93	66.4
1 – a positive outcome	38	27.1
2 – an absence of a result	9	6.4
Results on joint noises		
0 – no treatment	88	62.9
1 – a positive outcome	22	15.7
2 – an absence of a result	30	21.7
Results on limited jaw movements		
0 – no treatment	94	67.1
1 – a positive outcome	44	31.4
2 – an absence of a result	2	1.4
Results on kinematic disorder		
0 – no treatment	95	67.9
1 – a positive outcome	18	12.9
2 – an absence of a result	27	19.3
Results of kinesiotherapy		
Results on muscle pain		
0 – no treatment	83	59.3
1 – a positive outcome	35	25
2 – an absence of a result	22	15.7
Results on joint pain		
0 – no treatment	108	77.1
1 – a positive outcome	21	15
2 – an absence of a result	11	7.9
Results on joint noises		
0 – no treatment	85	60.7
1 – a positive outcome	45	32.1
2 – an absence of a result	10	7.1
Results on limited jaw movements		
0 – no treatment	109	77.9
1 – a positive outcome	14	10
2 – an absence of a result	11	12.1
Results on kinematic disorder		
0 – no treatment	91	65
1 – a positive outcome	40	28.6
2 – an absence of a result	9	6.4
Results of medication		
Results on muscle pain		
0 – no treatment	69	49.3
1 – a positive outcome	66	47.1
2 – an absence of a result	5	3.6
Results on joint pain		
0 – no treatment	107	76.4
1 – a positive outcome	26	18.6
2 – an absence of a result	7	5
Results on joint noises		
0 – no treatment	105	75
1 – a positive outcome	1	0.7
2 – an absence of a result	34	24.3

Supplementary Table S5. Treatment results (continuation).

	Frequency (n)	Percent (%)
Results on limited jaw movements		
0 – no treatment	109	77.9
1 – a positive outcome	19	13.6
2 – an absence of a result	12	8.6
Results on kinematic disorder		
0 – no treatment	112	80
1 – a positive outcome	1	0.7
2 – an absence of a result	27	19.3
Swallowing re-education		
0 – no treatment	76	54.3
1 – a positive outcome	40	28.6
2 – an absence of a result	24	17.1
Remission of the main symptom		
0 – no treatment	24	17.1
1 – a positive outcome	116	82.9
2 – an absence of a result	0	0