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Impact of sound production by wind instruments on the temporomandibular system of male instrumentalists[1]

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Abstract.
BACKGROUND: Playing a wind instrument can be either a reason for overuse or a protecting factor against certain diseases. Some individuals have many findings but low morbidity while others have few findings but high morbidity. This contradictory phenomenon should be researched.
OBJECTIVE: The temporomandibular system (TMS) is a functional unit which comprises the mandible, associated muscles and bilateral joints with the temporal bone. The TMS is responsible for the generation of sound when wind instruments are played. Over the long-term and with intensive usage, this causes changes in the musculature and in the temporomandibular joint (TMJ) of wind musicians, often resulting in temporomandibular disorders (TMD). The aim of this study is to examine evidence that TMD constitute an occupational disease in wind musicians.
PARTICIPANTS: TMD patients and wind musicians were examined by dental clinical functional analysis. 102 male subjects were divided into three groups: "healthy" individuals, wind musicians, and patients with TMD.
METHODS: Dental Examination was carried out based on focused inclusion of the research diagnostic criteria – TMD [1,7]. Findings were evaluated for statistical significance by first transferring data into a digital database [2,15], then generating T-Test und Wilcoxon-Test when non-Gaussian distribution appears and applying the Mann-Whitney rank sum test using Sigmaplot Version 11 software (Systat Software Inc, Washington, USA).
RESULTS: The evaluation revealed that wind instrument musicians show a high incidence of developing TMD as the researchers found almost 100% morbidity regarding parafunctional habits and preauricular muscle pain of each adult and highly active musician. The result is highly significant ($p < 0.001$) for protrusion distance of the mandible.
CONCLUSIONS: A higher prevalence of functional disorders of the musculoskeletal system has previously been demonstrated in wind musicians. New research results and the typical functions of various wind instruments provide evidence that playing a wind instrument generates occupational risks to the TMS.

Keywords: Wind instruments, sound generation, temporomandibular system, temporomandibular joint, temporomandibular disorders, jaw muscles, prevalence

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1. Introduction

Making music, either as a serious amateur or professional, requires both education and practice at the same intensity and duration as that required for high-level sports. It is one of the most complex activities of the human musculoskeletal system [12,26]. Musicians are often required to adopt a non-physiological posture, as the classic musicians' sitting position is rigid and motionless with restricted movement. In such a strenuous and cramped position they are required to play their instrument adequately over extended periods of time. With wind musicians, this setting is even more challenging since they need to employ their facial and jaw musculature continuously to generate sound.

The physical and mental exposure to overload is worsened by high noise levels, crowded orchestra seating, personal ambition, hierarchy in the orchestra (competition and low self-determination) and social uncertainty [8,12,16,26, Gassmann, M; Löffler C, unpublished data].

Furthermore, musicians suffer more from stress than average people. Musicians are exposed to different kinds of stress. They often have a very sensitive personality who identify greatly with their study and occupation [25].

The strong emotional personality of the orchestra musician must be adapted to the conductor's desires and musical tradition [8]. Performance stress can be the result of extraordinary demands on concert soloist and conductors [8]. Travelling for concerts is also an emotionally stressful working condition [24]. Music competition was considered to be an additional stress factor for generating playing-related musculoskeletal disorders (PRMD) (Gassmann, M, unpublished data).

One can estimate the prevalence of performance anxiety to be between 15% and 25% among all musicians [28]. All orchestra musicians suffer from distress caused by dynamic and non-physiological working conditions. In summary, musicians may be said to be highly affected by psychosocial distress. This can cause or aggrevate bruxism, muscular overuse and joint overload.

Overuse and distress lead to muscular *imbalance* caused by either hypertonus (high tension caused by straining) or hypotonus (low tension caused by poor conditioning)of involved muscles, such as antagonistic or contralateral muscles. This is an unavoidable and necessary result of practicing for many years to perfect instrument technique. Although there may be no discomfort initially, such overuse can become painful and incapacitating, and cause an occupational dysfunction of the TMS (Temporomandibular system) [26,27]. This is called a *temporomandibular disorder* (TMD). The dysfunction and its consequences constitute *temporomandibular dysfunction syndrome*.

It includes restricted function of chewing and articulation and pain in the masticatory and head stabilization muscles, parts of the TMJ (temporomandibular joint), and hypersensitive, overloaded teeth [1]. There is also a new definition which includes restricted function of playing a wind instrument (Pampel, M, unpublished data).

All together 128 specialized muscles are needed for sound generation, including 28 facial and 8 head stabilizing muscles (Pampel, M, unpublished data). 24 muscles, including the 8 jaw muscles, are used to adapt the lips and surrounding face parts to the mouthpieces of wind instruments (embouchure) [5].

The purpose of this study is to examine evidence to find whether playing a wind instrument predisposes an individual to TMD, and to determine whether various TMD findings were more frequent for wind musicians than for other TMD patients. The hypothesis is that wind musicians differ in their susceptibility to TMD compared to "normal" individuals.

Regarding previous research in this field, there exist about 2,000 articles addressing TMD. Approximately 200 scientific studies deal with musculoskeletal disorders that are related to music making. Research on TMD and wind musicians can be found in 18 publications, of which six are relevant for this study.

It must be noted that in the existing medical literature the term "function" was used for different medical problems and examinations such as lung function, chewing function, sound generation and musculoskeletal disorders (of the whole body). This is deceptive and imprecise referring to TMD because dentists focus on TMS and masticatory and head stabilizing muscles.

The 7-day prevalence of TMD, which means the incidence of at least one TMD event within one week, amounts to approximately 8% of the normal population. By contrast back pain is around 36% of the normal population. Pain for 65% of musicians in Brazilian symphonic orchestras was the maximum percentage [15]. A pilot population study revealed by calculation that 6.4% of the questioned non-musicians suffered from pain versus 29% of musicians [22].

Two reasons have been proposed as the cause of muscle pain: micro-trauma (rupture of small muscle fibers) and fatigue (hyperacidic muscle spasm or paralysis) [22].

Overall, 29% of musicians playing different instruments indicated significant pain [21].

Orofacial and TMD problems were reported by 11% of all musicians (various instruments) [9]. The prevalence of playing related musculoskeletal disorders (PRMD) is 39% to 47% in adult classical musicians, and 17% in pupils. This is comparable to the prevalence of work-related musculoskeletal disorders reported for other occupational groups [31].

The prevalence of parafunctional habits of the jaw and preauricular muscle pain in the healthy population was only 5–22%, which defined low prevalence [11, 13,17,19,20,29].

Embouchure problems as a dysfunction of the dentofacial complex were revealed for 26% of all wind musicians.

A prospective study of male wind musicians in Lebanon detected problems related to mouth and facial muscles: myospasms of cheek and lips were reported for 34.5% [10].

2. Methods

The study design was a cross-sectional design with a control group. Enrollment criteria required subjects to be of male gender and aged 18 years or older. Females were not included in this research into TMD due to the fact that their child-bearing age may be confounded by fluctuations in hormonal levels which may affect both perception of pain and the consistency of connective tissues. These factors have been found to greatly impact the resilience of the psyche, muscle and ligament reaction and thereby the generation of orofacial pain and muscular skeletal problems [31]. In the USA, 85% of patients affected by TMD have been reported to be female [14]. Furthermore, children and pupils are physically immature and musical exercise causes changes to the skull and the musculoskeletal system [4] Grown-up male subjects have less variable findings and therefore offer a better insight to TMD etiology and pathogenesis [16,18].

A stratified sampling strategy was used, consisting of three patient types: “healthy” patients, wind musicians, and patients with TMD. The following patients were examined: 33 wind musicians (18 professional musicians and 15 amateur musicians), 33 TMD patients, and 36 “healthy” patients. The difference between muscle function and load among professional and amateur musicians was not relevant for this initial study because performance and exercise time is non-physiological compared to normal individuals. On average, an amateur musician has a practice time of one hour per day – which amounts to one work day per week. This is a main part of work life and a distinct difference to non-musicians. Therefore both musician groups were combined to one group. Altogether, 102 male individuals were included. A written informed consent was obtained from each participant. The study was executed according to the guidelines of the local Ethics Committee. The sample sizes in each group were almost equal and were determined by the number of at least 100 for statistical evidence. When this study was started in 2004, the dental practice of the first author was designated as a Class I TMD center, and the data from the TMD patients examined during this period were used as controls in this study.

In German Class I TMD centers, patients of a dental practice build a population of average prevalence and significance, and the initial diagnosis is defined there. Class II TMD centers have some patients who are more affected by TMD than Class I patients, referred to the center by general dentists or via internet research carried out by the patient. The TMD-related statistical results of Class II TMD centers are of higher significance and severity. Class III TMD centers solely deal with patients affected by TMD of the highest degree. All patients of Class III centers come by referral of a first dentist, and the final diagnosis is determined there.

Evaluation of the wind musicians’ prevalence for TMD by the first author was stopped once the number of participants had surpassed 100, in order to create first valid data and then to prepare a prospective study. This was necessary in order to use the findings of this study in disproving claims of insurance companies that a wind musician suffering from TMD is only a single case and that TMD is not a typical occupational disease for this professional group.

The study was executed with reference to the method of Ahlers and Jakstat which contains physical examination, inspection and questionaires [1,2,6,7]. This dental clinical functional examination is the preferred method of evaluation for TMD because the jaw musculature is physiologically very different compared to the musculoskeletal system of the trunk and the extremities [30]. The examination was based on muscle palpation, jaw mobility, joint sounds and occlusion [1]. Distances (active and passive mouth opening) were measured in mm and are metric data. Clenching and grinding were nominal data.

All together, there were more than one hundred findings from case report forms and data were sub-

sequently computerized and processed. Only some of these findings have been analyzed today. Data relating to parafunctional and pathological findings like pain and joint sounds were evaluated using the CMD-fact diagnostic software Version 2.06 (dentaConcept, Hamburg, Germany) [2,15]. The existence and number of findings in each group of examined participants were statistically analyzed for significance. The data were arranged in columns or box plots to display the essential facts in an easily comprehensible form (Sigma Plot Version 11, Systat Software Inc.).

Palpation was examined ordinally (discomfort, pain), with the first author standing in a fronto-lateral position to the individual, using the fingertips of both middle fingers simultaneously and exerting gentle pressure ($\leqslant$ 200 g).

The evaluation and results were statistically descriptive. At the beginning of the study in 2004, significant results were not postulated by the authors. The first numerically analyzed findings were: Examination of joint sounds which were separated into pathologic crepitus, pathologic clicking, vertical and horizontal jaw mobility and the static or dynamic restriction of occlusion. Discomfort or tenderness upon palpation was evaluated by palpation of isometric muscle load. Examination of the main protrusive muscle, the lateral pterygoid muscle, was performed first. This was followed by examination of a laterotrusive muscle, the masseter profundus, and then of a retrusive muscle, the posterior digastric muscle.

The outcome variables were measured in distances for the vertical and horizontal jaw mobility.

Parafunctional habits and joint noise were counted per individual and evaluated as Yes or No answer. Joint sound means hearable or detectable vibrations by the dentist's finger tips. The patient can hear it in most cases, the dentist only in case of very ligament or disc displacement. Protrusion was measured in mm (distance). The percentage of individuals with positive findings was compared against all individuals of the group.

3. Results

The findings from this study show that almost all examined wind musicians have one or more signs of parafunctional habits (Fig. 1). Common parafunctional habits include the following:

Grinding is an isotonic activity of the jaw musculature and causes very small jaw movements by using the muscles for lateral and retral jaw movements which are the lateral pterygoid, masseter profundus, posterior digastric, and the medial und posterior temporalis muscles.

Clenching is described as an isometric contraction of the main jaw closing muscles, the medial pterygoid and the masseter muscles.

Clenching and grinding are muscular parafunctional habits caused by malocclusion or emotional stress. Both are elements of bruxism, which involves spastic contractions (Fig. 2).

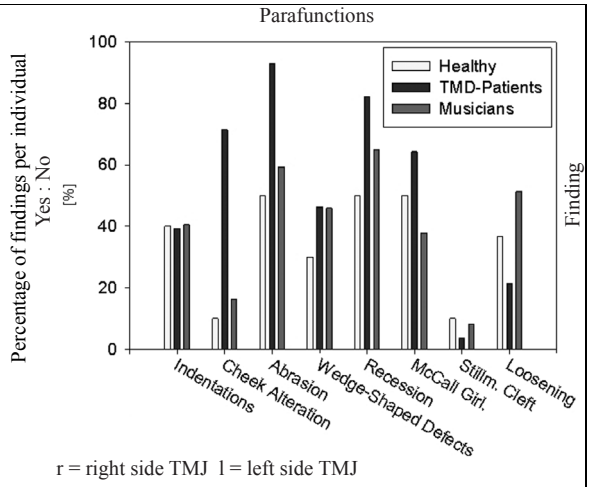


Fig. 1. *Parafunctions* are the symptom of overuse of the orofacial tissues. (Colours are visible in the online version of the article; http://dx.doi.org/10.3233/WOR-131621)

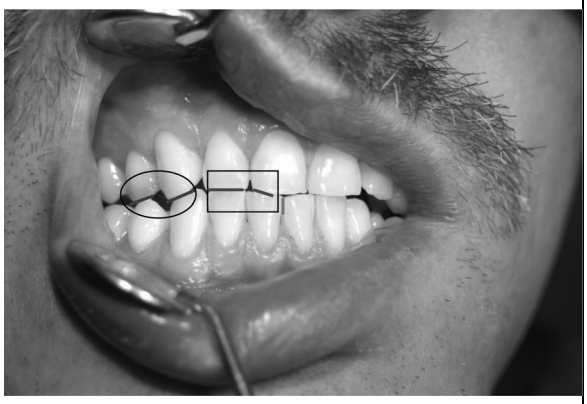


Fig. 2. Mandible and condyles were in a latero-excentric position. The musician was a high level amateur trumpet player and 53 years old. The teeth fit exactly in this key-lock position. *Clenching*: Yellow line: centre of maxillary dental arch. Green line: centre of mandibular dental arch. Red and blue lines: angles and planes of corresponding grinding facettes of upper and lower teeth. (Colours are visible in the online version of the article; http://dx.doi.org/10.3233/WOR-131621)

Fig. 3. *Indentations* in the tongue as a result of tongue thrusting, which is caused by psycho-social distress or occupational overuse. The musician was a 48-year-old clarinet and saxophone teacher. (Colours are visible in the online version of the article; http://dx.doi.org/10.3233/WOR-131621)

Fig. 4. *Abrasion* is caused by grinding, which is a muscular hyperactive habit during the night. Approximately 1.5 mm of enamel has been abraded before the dentine core is visible. (Colours are visible in the online version of the article; http://dx.doi.org/10.3233/WOR-131621)

Typical signs of the aforementioned parafunctional habits are:

- Indentations, which are impressions of the lower teeth into the tongue muscle as a result of tongue thrusting (Fig. 3).
- Abrasion, which is the result of an autodestructive grinding habit in an excentric jaw position (Fig. 4).
- Recession, which is the gingival retraction caused by bruxism and results in clinical attachment loss (Fig. 5).
- Stillmann Cleft, which is a localized vertical cleft of the periodontal ligament caused by a lack of vascular supply. These excessive and multiple clefts are a *new* sign of excessive parafunctions (in wind musicians) (Fig. 6).
- Mc Call Girlande, which is an arched gingival hyperplasia of the gingival margin (Fig. 7).
- NEW: Hyperceratotic gingival hyperplasia in near of the apex, which is a new finding for wind instrumentalists as proof of the dysfunctional overuse of the periodontium and the oral soft tissues (Fig. 8).

Fig. 5. *Recessions* and *wedge shapeddefects* at the neck of the lateral teeth. The musician was a 45-year-old clarinet and saxophone player and professional teacher.Red line: cementoenamel junction. Red arrow: missing gingiva, bone and periodontal ligament. (Colours are visible in the online version of the article; http://dx.doi.org/10.3233/WOR-131621)

Fig. 6. NEW: The *Stillman Clefts* are extraordinary in location and number. They are caused by excessive grinding while sleeping and tongue pressure towards the palatal roof and the anterior teeth of this base trombone player.Red arrow: Partial ruptures of soft tissues of periodontal ligament. (Colours are visible in the online version of the article; http://dx.doi.org/10.3233/WOR-131621)

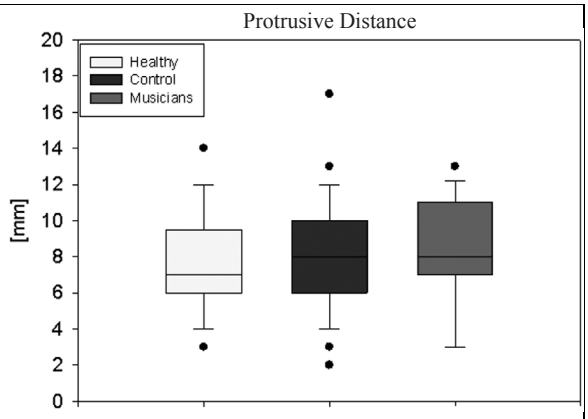
The mean protrusion of wind musicians was 9.9 mm. It is a sign of high mandibular mobility and of a very high exercise level of the muscles and demonstrates good adaptation to the occupational needs. In protru-

Fig. 7. *McCall Girlande* in the lower jaw of a 34-year-old oboe soloist of a philharmonic orchestra. This hyperplastic gingiva is caused by overuse and bacterial inflammation. (Colours are visible in the online version of the article; http://dx.doi.org/10.3233/WOR-131621)

Fig. 8. NEW: *Hyperceratotic Gingiva Hyperplasia (HCGH)* of a 45-year-old amateur base trombonist. This soft tissue alteration was situated caudal to the mucogingival junction. It was effectively attached: White, permanent and not removable. It corresponded with the root apex of the incisors. (Colours are visible in the online version of the article; http:// dx.doi.org/10.3233/WOR-131621)

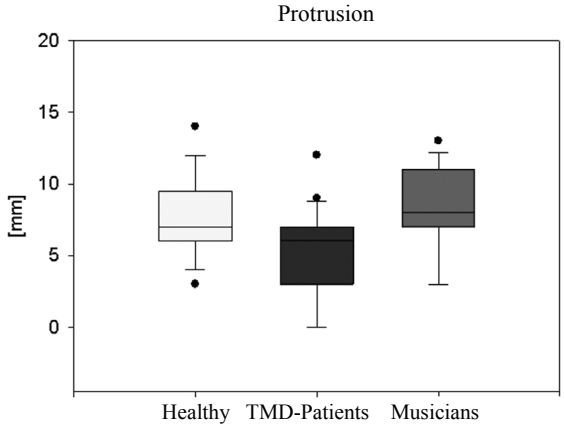
sion, the difference in median values between the two control groups is greater than would be expected by chance; statistically there is a highly significant difference ($p < 0.001$) (Figs 9 and 10).

Examination of the temporomandibular joint (TMJ) for pathologic conditions revealed thefollowing results: The physiological function of the TMJ is to silently maintain the fossa, cartilage (discus articularis) and condyle in a dynamic but stable contact during mandibular movement. The pathologic situation is anterior displacement of the intra-articular disc in the TMJ. Internal disc derangement may take two forms: Anterior disc displacement with reduction during function (accompanied by clicking or popping sounds on opening and closing the mouth) and without reduction, which is characterized by painful limitation of jaw movement.



Protrusion 1: Class I TMD Center (Coburg) as Control
G = Healthy K = Control M = Musicians

Fig. 9. *Protrusion 1* When the control group was a ClassI TMDcenter (Coburg) it was be determined that the median protrusive distance of musicians is 9.9 mm which is greater than the value of the other groups. The standard deviation is four times higher than healthy individuals and three times higher than TMD patients. The statistical difference is not significant. (Colours are visible in the online version of the article; http://dx.doi.org/10.3233/WOR-131621)



	Healthy	Control	Musicians
Mean	7,53448276	5,28571429	9,92592593

Protrusion 2: Class III TMD Center (Hamburg-Eppendorf) as Control Mann-Whitney Rank Sum Test

Fig. 10. *Protrusion 2* When the control group was a ClassIIITMDcenter (Hamburg-Eppendorf) it was determined that for the protrusion the difference in the median values between the two control groups is greater than would be expected by chance; there is a highly significant difference ($P \leqslant 0.001$). (Colours are visible in the online version of the article; http://dx.doi.org/10.3233/WOR-131621)

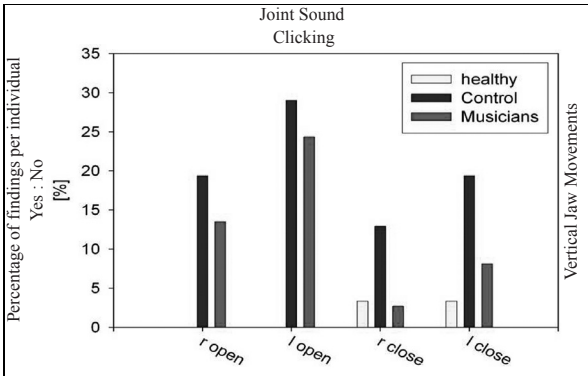


Fig. 11. *Clicking* is a non-physiological sound caused by pathologic discus *derangement*. The graph shows the statistical evaluation. (Colours are visible in the online version of the article; http://dx.doi.org/10.3233/WOR-131621)

The occurrence of clicking sounds differs a little between the musicians' group and the TMD group while opening at right side (13.5% versus 19.4%). Musicians experienced more clicking while opening the jaw than while closing. This was similar in the left joint (24.3% versus 29%). While closing the difference between musicians and the TMD group was even greater: right side 2.7% versus 12.9%; left side 8.1% versus 19.4% (Fig. 11).

The masseter muscle of musicians showed pain at the right side in 27% and 19% at the left side.

The masseter profundus of musicians revealed in 51.4% pain following to palpation. The TMD group revealed 45.2%.

The results reported here are preliminary and refer to a population of 102 individuals used to generate first data.

4. Discussion

There was great difference in the results when using the patients' data from a Class III TMD center (Hamburg-Eppendorf) as control group compared to patients' data of a Class I TMD center (Coburg):

> For example, the mandibular protusion distance which is a requirement for wind instrument embouchure is highly significant. Plus, the incidence of parafunctional habits almost reached 100%.

The findings are placed in the context of previous research on TMD involving normal individuals and (wind) musicians.

However the results were not statistically significant.

The percentage of joint clicking while opening the mouth was almost similar between musicians and TMD patients which proves that musicians are as much affected as diseased individuals.

While closing the mouth, clicking appeared in the control group more than twice as much at left side and almost six times as much at the right side which could be stated as evidence for displacement without reduction in musicians' joints.

Musicians demonstrated the highest percentage of tenderness to palpation in the masseter muscle which was greater than of TMD-patients [22].

The musicians' masseter profundus as laterotrusive muscle was affected even more than of diseased individuals. This is a proof for overuse by grinding and clenching [23].

The results were a proof of the high prevalence experienced by musicians compared to healthy or average people [11,20].

This revealed that TMD research and different study designs are difficult to compare and that the outcome is heterogeneous. One reason may be that the focus was not on the TMS but on the musculoskeletal system of the whole body because most researchers on PRMD were physicians, not dentists.

As the masseter muscle showed the greatest amount of muscle pain following palpation, this revealed evidence for clenching and grinding as an underlying reason of the TMD because the Masseter is the main closing muscle.

5. Conclusion

This research was intended to answer the question if and how the jaw musculature reacts in a different way than other muscles and if this differs between wind musicians and other individuals. The results indicate that wind musicians are at increased risk of losing muscular balance in the TMS and of becoming injured when pathological findings increase. In patients with TMD, the distance of mandibular protrusion is not restricted compared to healthy individuals; but in patients with severe TMD which is defined by a maximum number of findings and restriction of jaw motion and pain, the distance of mandibular protrusion is restricted; however, the protrusion of wind musicians is significant, which shows a great range of motion in the TMJ and a high adaptation capacity of the TMS. The rotation is normal, but the translation is unhealthy which means that patients have preauricular pain.

Wind musicians experience severe TMD, comparable to the patients of a class III TMD center. Almost 100% of wind musicians show signs of parafunctional habits in their TMD. New signs of parafunctional habits can be considered to be characteristic of wind instrument musicians. The results reported here are preliminary and refer to a population of 102 individuals used to generate first data.

In summary, the results are heterogeneous; the results do not show a clear correlation between individual techniques of playing a wind instrument and TMD. An exact understanding of the origin of TMD in wind musicians is still required. However, this study provides evidence for the etiology of TMD among wind musicians.

For wind musicians dental clinical functional analysis is required to address TMD because all suffer from overuse and overload of their TMS by non-physiological demands [27].

Musicians suffering from TMD need sufficient therapy such as dental functional analysis and therapy, physical therapy, psycho-therapy, analgetic medication, thermotherapy and rehabilitation [29].

In cases of malocclusion, bruxism, oral habits, embouchure problems, TMD, occlusopathy, periodontitis, tooth loss and loosening, orthodontic and prosthodontic indications, sufficient treatment strategies addressing hard tissues only can be derived from dental medicine and be fulfilled by experienced and specialized dentists.

In order to avoid malocclusion, tooth loosening or loss, and to avoid the development or worsening of bruxism and related problems, it is necessary to establish a health education and stress compensating program and to institute preventive measures for professional wind musicians [3,18].

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