Medical university –Varna
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Faculty „Dental medicine”
Department “Dental Material Science and Propaedeutics of Prosthetic Dental Medicine“

Tinnitus and auditory changes in patients with temporomandibular joint dysfunction

SUMMARY
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The dissertation contains 173 standard pages and is illustrated with 9 tables and 89 figures, 4 photos and 4 appendices. The literature reference includes 325 literary sources, of which 20 in Cyrillic and 305 in Latin.

The dissertation is discussed and directed to the defense of the Department Council of the Department of " Dental Material Science and Propaedeutics of Prosthetic Dental Medicine" at Medical University "Prof. Dr. Paraskev Stoyanov "- Varna on 04.02.2021

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The official defense of the dissertation will be held on 18.04.2022 at 13:00 in the Faculty of Dental Medicine at an open meeting of the Scientific Jury.

The materials on the defense are available in the Scientific Department of Medical University - Varna and are published on the website of Medical University - Varna.

Note: In the abstract the numbers of the tables and figures do not correspond to the numbers in the dissertation.

CONTENTS

LIST OF ABBREVIATIONS:

BMI – body mass index

CT - computed tomography

NSAIDs - non-steroidal anti-inflammatory drugs

WHO - World Health Organization

TMJ - temporomandibular joint

ENT - ears, nose and throat

HRT - hormone replacement therapy

MRI - magnetic resonance imaging

CBCT – cone-beam computed tomography

SOAE – spontaneous otoacoustic emissions

TMD – temporomandibular dysfunction

DCN – dorsal cochlear nucleus

INTRODUCTION

Tinnitus is the perception of noise, which can be generated by pathological changes in various levels of the acoustic system, changes in the vascular or velo-palatal muscles, as well as changes in the temporomandibular joint (TMJ). For this reason, tinnitus is not considered a separate disease, but only a symptom with many etiological factors. It is considered a manifestation of various diseases, including TMJ dysfunction. It can manifest as a simple noise without clinical complaints or intense enough to interfere with the individual's social activities, making it a socially significant disease. Up to 50% of tinnitus cases are of unknown etiology, but are increasingly associated with temporomandibular joint dysfunction (TMD).

The global prevalence of tinnitus reaches 14 - 32%. It occurs at any age and increases with the senile changes. Tinnitus can affect both men and women.

The US Public Health Agency discussed the condition, described as tinnitus, in 1984 and 1985 as the third most uncomfortable condition that has a negative impact on lifestyle.

As the etiology of temporomandibular joint disorders is multifactorial, collaboration between different health professionals and the application of an interdisciplinary approach to alleviate tinnitus and other otological symptoms associated with temporomandibular joint disorders are needed. Proper diagnosis of the etiology of tinnitus is essential for its adequate treatment.

Conservative evidence-based management of temporomandibular dysfunction (TMD) should focus on the multifactorial etiology of the pathology. Biological, psychological and social factors may play a role in the etiology and duration of TMD. The entire diagnostic process in patients with tinnitus should be accompanied by multidisciplinary timely consultation, including with a dentist.

AIM AND TASKS

Aim

The aim of the dissertation is to study and evaluate the correlation between problems in the temporomandibular joint and tinnitus in patients with audiovestibular diseases.

Tasks

1) To systematize demographic and clinical information for patients undergoing prosthetic treatment in connection with temporomandibular dysfunction (TMD).
2) To examine patients with tinnitus:
   - to assess tinnitus;
   - to investigate TMJ dysfunction.
3) To investigate and evaluate the relation between tinnitus and TMJ dysfunction.
4) To assess a risk profile of patients with tinnitus and TMJ dysfunction.
5) To create an algorithm for the diagnosis of patients with tinnitus and TMJ dysfunction enriched with a closely specialized diagnostic protocol for TMD in collaboration with an ENT specialist.

MATERIAL AND METHODS

MATERIAL

For the purposes of this dissertation we examine tinnitus of patients who underwent dental treatment and with dysfunction of the temporomandibular joint according to: age, sex, dental treatment, the presence of risk factors. All patients are clinically examined and evaluated on various indicators, depending on the tasks.

The object of the study on the first task are 152 patients who have passed through the clinical halls of the FDM - Varna for a period of two years (2019 - 2020).

The object of the study on the other tasks are 150 patients who passed through the clinical halls of the Faculty of Dental Medicine - Varna, University Medical and Dental Center and the audiovestibular laboratory at the Faculty of Dental Medicine - Varna. The selection of participants is based on well-defined criteria.

a) Inclusion criteria

- Persons over 18 years of age;
- With tinnitus;
- With complaints in the area of the temporomandibular joint;
- With audiovestibular diseases;
- With completed informed consent.

b) Exclusion criteria

- Persons under 18 years of age;
- Without audiovestibular diseases;
- Without tinnitus;
- Without complaints in the area of the temporomandibular joint;
- Persons who have not filled in an informed consent.

All participants in the study had a history, dental examination and examination by an otolaryngologist.

In performing the **first task – to systematize demographic and clinical information for patients undergoing prosthetic treatment** in FDM and UMDC - Varna for a period of 2 years, in relation to temporomandibular dysfunction (TMD):

- **The subject of the study** are 152 patients who have passed through the clinical halls of FDM - Varna and have undergone prosthetic treatment**.**
- **Observation unit –** sex, age, concomitant diseases (diabetes, joint diseases), reasons for visiting the dentist's office, reasons for the need for prosthetic treatment, causes of tooth loss, parafunctions (bruxism, bruxomania), TMJ condition (pain, clicking, trismus)
- **Place of study –** clinical halls of prosthetic dental medicine of FDM - Varna.
- **Study time –** 2019 – 2020 incl.

In connection with the **second task – to assess tinnitus in the studied patients:**

- **The subject of the study** are 150 patients who were examined by an otolaryngologist.
- **Observation unit –** tinnitus;
- **Place of study –** University Medical and Dental Center and the audiovestibular laboratory at the Faculty of Dental Medicine - Varna at Medical university - Varna.
- **Study time –** 2020 – 2021 incl.

In performing the **second task – to examine TMJ dysfunction:**

- **The subject of the study** are 150 patients;
- **Observation unit –** pain in the area of TMJ.
- **Place of study –** University Medical and Dental Center and the audiovestibular laboratory at the Faculty of Dental Medicine - Varna at Medical university - Varna.
- **Study time –** 2020 – 2021 incl.

In performing the **third task – to investigate and evaluate the relation between tinnitus and TMJ dysfunction:**

- **The subject of the study** are 150 patients;
- **Observation unit –** the correlation between TMJ dysfunction and tinnitus in patients undergoing prosthetic treatment.
- **Place of study –** University Medical and Dental Center and the audiovestibular laboratory at the Faculty of Dental Medicine - Varna at Medical university - Varna.
- **Study time –** 2020 – 2021 incl.

In connection with the **fourth task – to assess a risk profile of patients with tinnitus and TMJ dysfunction.**

- **The subject of the study** are 150 patients;
- **Observation unit – the main etiological factors** influencing tinnitus and TMJ dysfunction.
- **Place of study –** University Medical and Dental Center and the audiovestibular laboratory at the Faculty of Dental Medicine - Varna at Medical university - Varna.
- **Study time –** 2020 – 2021 incl.

In performing the **fifth task – to create an algorithm for the diagnosis of patients with tinnitus and TMJ dysfunction,** enriched with a closely specialized diagnostic protocol for TMD in collaboration with an ENT specialist:

- **The subject of the study** are 150 patients;
- **Observation unit –** the analyzes, clinical examinations and questionnaires performed so far, on the basis of which an algorithm for diagnosis of patients with tinnitus and TMJ dysfunction has been created, enriched with a closely specialized diagnostic protocol of TMD in collaboration with ENT specialist.
- **Place of study –** University Medical and Dental Center and the audiovestibular laboratory at the Faculty of Dental Medicine - Varna at Medical university - Varna.
- **Study time –** 2020 – 2021 incl.

METHODS

For task 1: To systematize demographic and clinical information for patients undergoing prosthetic treatment in FDM and UMDC - Varna for a period of 2 years, in relation to temporomandibular dysfunction (TMD):

A detailed ambulatory card created for the purpose of the study is completed for each patient (Appendix 1). It includes information about name, sex, age, concomitant diseases (diabetes, joint diseases), reasons for visiting the dentist's office, reasons for the need for prosthetic treatment, reasons for tooth loss, parafunctions (bruxism, bruxomania), TMJ condition (pain, clicking, trismus).

For task 2: To assess tinnitus in the studied patients:

The assessment of tinnitus was performed using a specialized questionnaire, which is completed by the patient (Appendix 2). The purpose of this questionnaire is to determine whether tinnitus has any effect on patients' mood, habits and behavior. The questions are evaluated on a three-point scale: 0 – false, 1 – partly true and 2 – true. The points are summed in a general assessment, which determines the degree of influence of tinnitus:

I degree of severity - minor violations - 0 - 7 points;

II degree of severity - moderate violations - 8 - 12 points;

III degree of severity - serious violations - 13 - 18 points;

IV degree of severity - very severe violations - 19 - 24 points.

In addition, the patients underwent two functional examinations - tympanometry and audiometry by an ENT specialist.

Tympanometry is a diagnostic procedure used to assess the condition of the middle ear. Sound waves are directed to the tympanic membrane and their reflection is recorded back through the auditory canal (Photo 1 and photo 2). At the same time, the response to changes in pressure is reflected.

Photo 1. Conducting a tympanometer examination in an office for examination of hearing disorders (audiovestibular laboratory in UMDC at FDM - Varna)

Photo 2. Tympanometer

The result is expressed graphically by tympanogram and audiogram (Fig. 1).

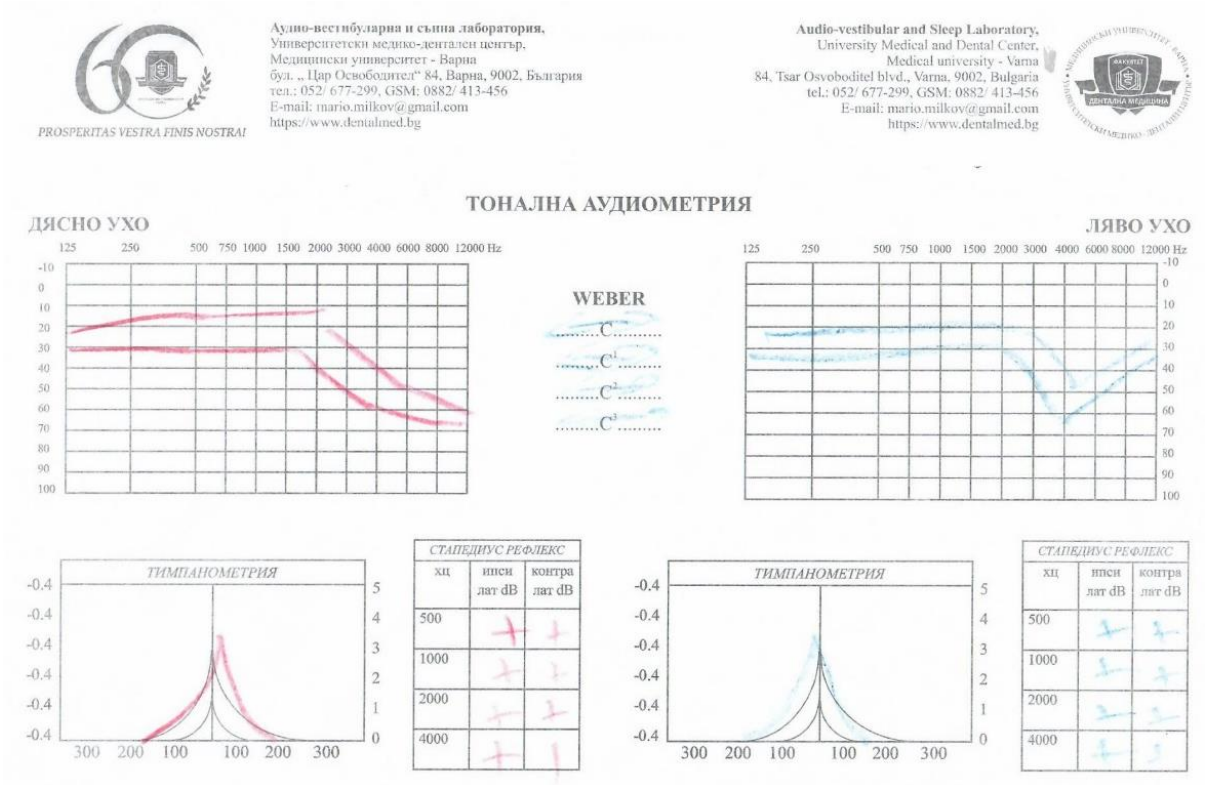

Fig. 1. Results of audiometry and tympanometry performed in the audiovestibular laboratory in UMDC - Varna at FDM – Varna

The healthy tympanic membrane reacts with movement, the pressure in the middle ear is in the range of +50 to -150 daPa (decapascals). The eardrum has a smooth surface. The tympanogram shows normal values of pressure in the middle ear and normal sound conductivity. This type of tympanogram is defined as type A.

In the presence of fluid or exudate in the middle ear, the tympanic membrane remains immobile, does not react with vibrations to changes in pressure and sound wave. Deviations from the norm are also found in the case of blockage of the Eustachian tube, which connects the middle ear to the throat. As a result of its dysfunction, negative pressure is created in the middle ear, which is associated with characteristic changes in the tympanogram. Tympanograms type B and C report pathological changes such as perforation of the tympanic membrane, adhesions in the membrane, exudate or lack of contact between the auditory bones in the middle ear (malleus, incus and stapes), tumor process in the middle ear.

Audiometry is a subjective method of examining the auditory analyzer. For audiology, the determination of the level of the possible lesion, the degree of impaired sound perception, prospective follow-up and the probable prognosis are particularly important.

The purpose of audiometry is as follows:

- Making diagnosis of the level of the hearing defect;
- Clarification of the functional state of the auditory analyzer and giving a forecast;
- Statement of the treatment methods for elimination of the defect with evaluation of the prognosis for the effectiveness;
- The possibility of hearing prosthetics and the possibility of cochlear implantation;
- Defining some medical and social conclusions such as simulation, ability to work and professional organization;
- Prophylactic studies related to the periodic examination of hearing in patients exposed to pathogenic noise, in the application of ototoxic antibiotics and other toxic to the inner ear drugs and therapeutic agents.

It examines both the intensity (volume) and frequency of the sound that the patient can hear, as well as balance problems and other conditions related to inner ear function (Photo 3 and photo 4).

Photo 3. Conducting an examination with an audiometer in an office for examination of hearing disorders (audiovestibular laboratory in UMDC at FDM - Varna)

Photo 4. Audiometer

The unit of measurement for sound intensity is decibels (dB). A healthy human ear can hear quiet sounds (such as whispers) - about 20 dB, and loud sounds (like a jet engine) - between 140 and 180 dB. Fig. 2 presents the result of the conducted examination with an audiograph.

The audiometer is a complex electronic converter, which has the ability to deliver pure tones with a certain strength and frequency through built-in generator, amplifier and additional modules to form the nature of the delivered tone. The minimum intensity of the audiometer is in accordance with the normal minimum hearing threshold and starts at 10 dB. Below this threshold (refers to air bone conduction) the relative decibel scale is used. The maximum intensity is not the same for all audiometers, so it is specified by each manufacturer. Each audiometer contains an air conduction headset and a bone vibrator for bone conduction testing. The examination is performed in the soundproof room of an office for examination of hearing disorders (audiovestibular laboratory in UMDC at FDM Varna). At the discretion of the audiologist or ENT patient, additional tests such as: OAE, cVEMP, o VEMP, BERO may be ordered.

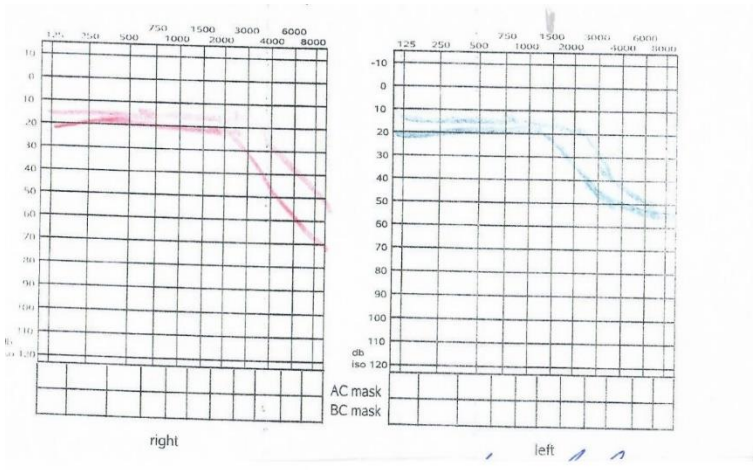

Fig. 2. Result of the performed audiography

The frequency of the sound is determined by the number of oscillations per second. The unit of measurement for the frequency of sound is hertz (Hz). Low bass tones have a frequency of about 50 Hz. Every individual can hear tones in the range of 20 to 20,000 Hz. Human speech usually falls in the range between 500 - 3000 Hz:

- Norm (from -10 to +20 dB)
- Slightly reduced hearing (from +20 to +40 dB)

- Medium hearing loss (+40 to +70 dB)
- Severe hearing loss (from +70 to +90 dB)

For task 2: To investigate TMJ dysfunction.

The clinical examination of patients with functional pathology includes bilateral palpation of TMJ, performed according to the first method presented in our country (Fig. 3). The palpation points from point 1 to point 5 were examined as follows:

- P. 1 The lateral part of the tuberculum articulare is palpated - the upper grip of the joint disc and the anterior area of the synovial capsule. M. pterygoideus lateralis - pars superior is caught for the synovial capsule above the anterior edge of the discus articularis, and pars inferior is caught for the articular head. Pain in this area is an indicator of dysfunctional changes, most often associated with hypermobility in the TMJ.
- P.2 The lateral part of the anterior upper edge of the caput mandibulae is palpated - the lower grip of the joint disc and the lower insertion of the joint capsule to the joint head are examined.
- P. 3 The lateral pole of the caput mandibulae is also studied.
- P.4 An important step in the clinical diagnosis of TMJ is the study of provoked symptoms in the distal part of lig. collaterale laterale.
- P.5 The lateral retrodiscal portion of the TMJ is palpated laterally.

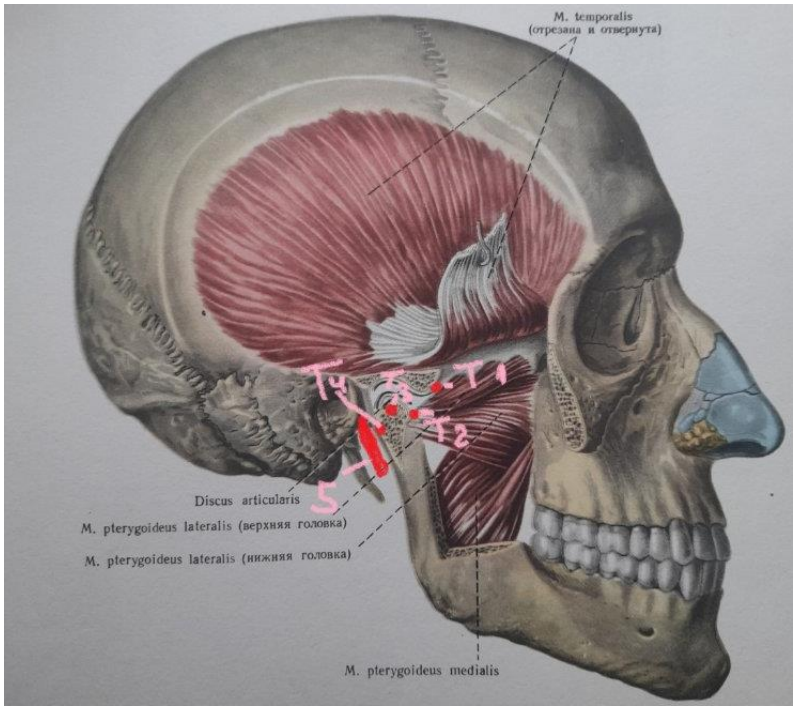

Fig. 3. Bilateral palpation points of the TMJ

Prior to palpation at the aforementioned points, patients subjectively locate the problem area by pointing to the location of the pain.

In patients for whom objective data from the clinical examination are suspicious for disposition of the articular disc with or without repositioning, a paraclinical examination is ordered - radiography of the TMJ (Fig. 4).

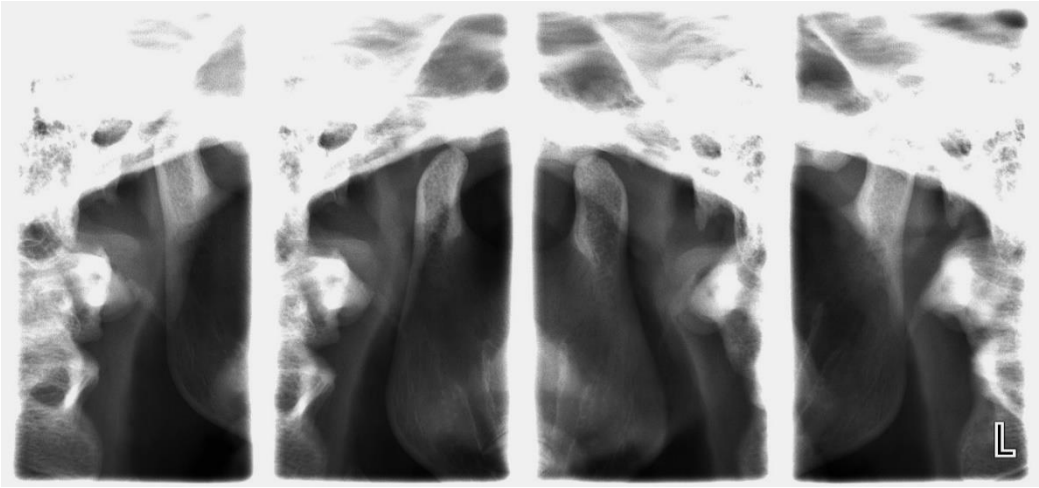

Fig. 4. Radiography of the TMJ

For task 3: To investigate and evaluate the correlation between tinnitus and TMJ dysfunction.

To perform this task, the correlation between the results of the study of tinnitus, tympanogram, audiogram and the five points at which TMJ dysfunction was studied are analyzed. The results obtained from the completed questionnaires, the conducted clinical examinations and paraclinical studies, which were statistically processed, were used, using the statistical methods described below.

For task 4: To assess a risk profile of patients with tinnitus and TMJ dysfunction.

The results obtained from tasks 1, 2 and 3 were used to create the risk profile of patients with tinnitus and TMJ dysfunction. A statistical method (Odds Ratio) was applied, allowing a hierarchy of results.

For task 5: To create an algorithm for the diagnosis of patients with tinnitus and TMJ dysfunction, enriched with a closely specialized diagnostic protocol for TMD in collaboration with an ENT specialist.

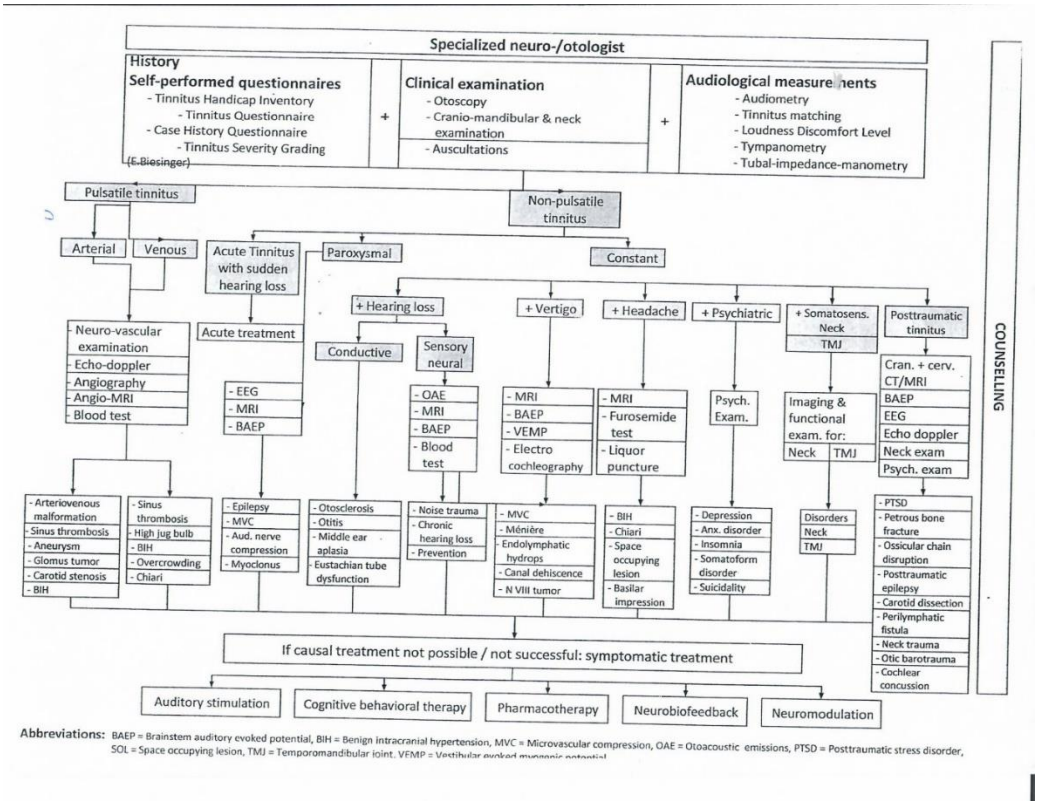

Fig. 5. Form for examination of patients with tinnitus, approved and accepted in the audiovestibular laboratory in UMDC - Varna at FDM - Varna

Based on the obtained data (Fig. 5) and the summarized results of the conducted research and the prepared risk profile of the patients, an algorithm for diagnosis of patients with tinnitus and TMJ dysfunction was created through collaboration between dental and other medical specialists. A closely specialized diagnostic protocol of TMD has been created in collaboration with an ENT specialist.

Statistical methods - for all tasks

The results were processed with SPSS v. 20.0, using the following analyzes:

- Dispersion analysis (ANOVA);
- Variation analysis - arithmetic mean ± standard deviation (mean±SD);
- Correlation analysis - Pearson's ratio and Spearman's ratio
- Regression analysis - univariate linear regression
- Risk analysis - Odds Ratio (OR)
- Comparative analysis (hypothesis evaluation)– $\chi 2$, F and t-test.
- Graphic and tabular method of displaying the obtained results

In all analyzes performed, an acceptable level of significance $p < 0.05$ is assumed.

RESULTS AND DISCUSSION

To systematize demographic and clinical information for patients undergoing prosthetic treatment in FDM and UMDC-Varna for a period of 2 years, in relation to temporomandibular dysfunction (TMD):

For the studied period 152 patients with a mean age of 60.5 years ± 12.8 years (25 years - 90 years) passed through the clinical halls and UMDC - Varna, as the distribution is presented in Fig. 6.

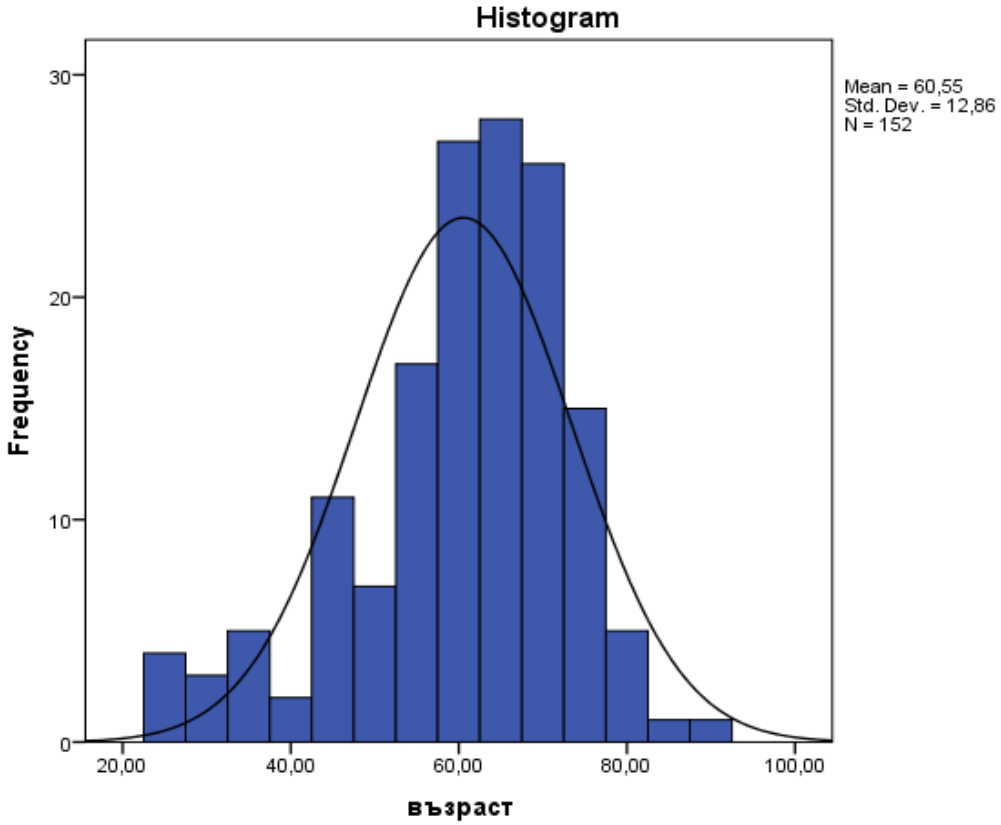

Fig. 6. Distribution according to the age of the patients

About 2/3 (62.5%) of the examined patients are women. Although no significant difference was found in terms of mean age, it can be said that women who underwent prosthetic treatment are younger than men (Fig. 7). The mean age of women is 59.4 years and that of men is 62.3 years.

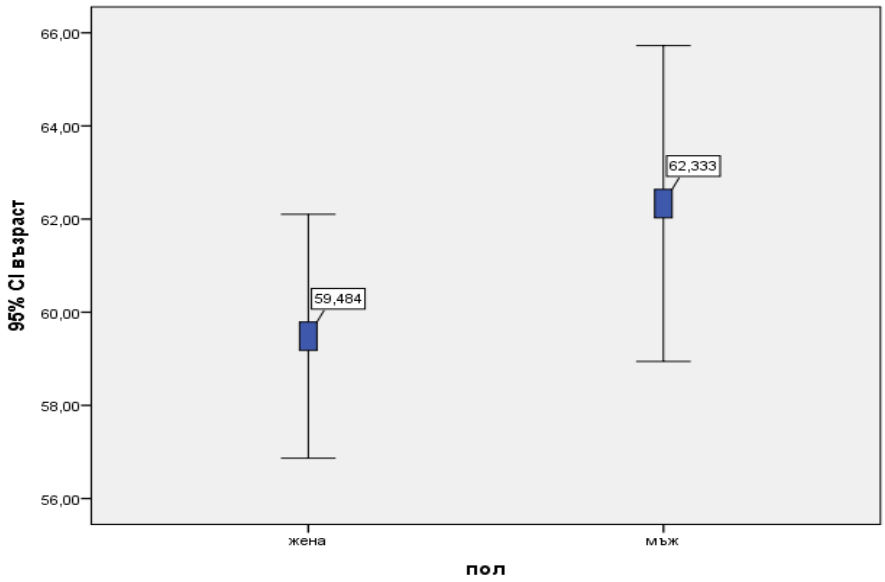

Fig. 7. Mean age of the patients underwent prosthetic treatment

In half of the patients the main cause of tooth loss is periodontal disease (54.3%). In 42.9% this reason is carious lesions of the hard dental tissues and their complications. Only in 2.90% of the examined patients the cause of premature tooth loss was associated with trauma (Fig. 8).

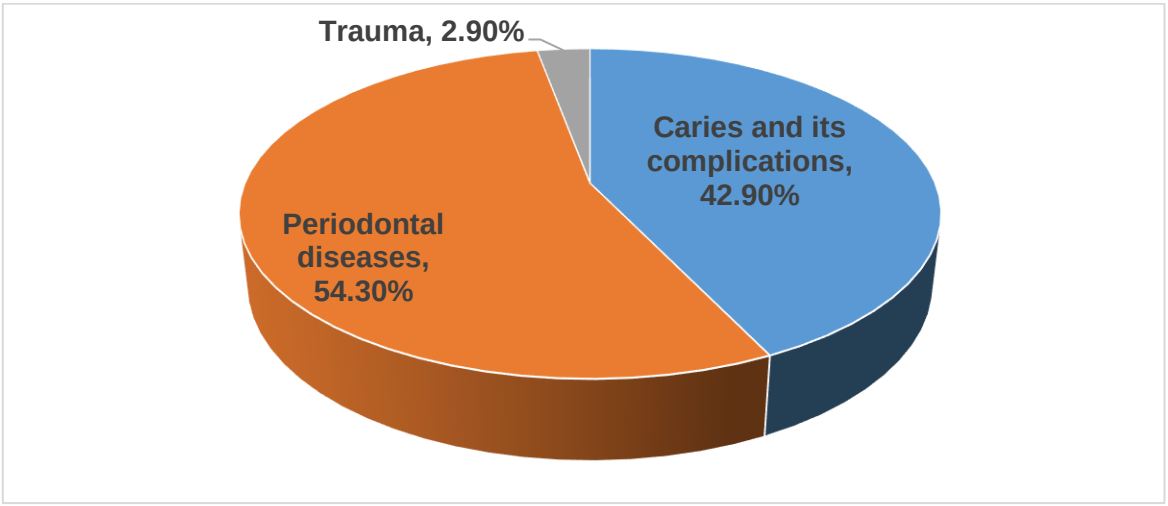

Fig. 8. Distribution according to the cause of tooth loss

Patients with trauma are younger than others (54.7 years), while the mean age of those with tooth loss due to periodontal disease is 61.8 years, and patients who have lost their teeth due to carious lesions and their complications are at a mean age of 58.2 years ($p = 0.042$). There is no difference in the causes of tooth loss by sex.

Slightly more than half of the patients underwent prosthetic treatment with partial dentures (53.9%), while the rest underwent treatment with total dentures. Sex dependence was not established until, in terms of age, the mean age was 64.5 years for patients treated with full dentures and 57.2 years for partial dentures (p <0.001) (Fig. 9).

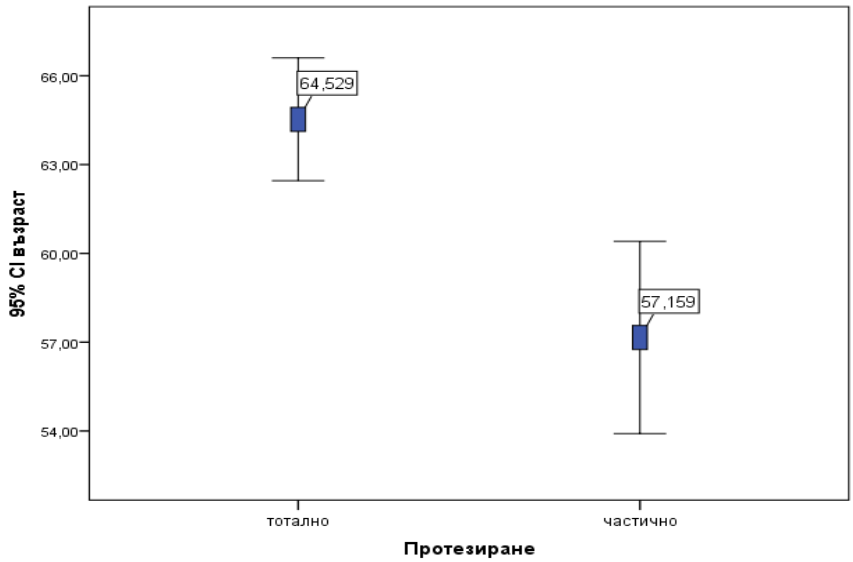

Fig. 9. Mean age of patients according to the performed prosthetic treatment

A significant difference was found between the treatment and the causes of tooth loss (p = 0.032) (Fig. 10). About 2/3 (63.8%) of the patients who underwent treatment with total dentures lost their teeth due to periodontal disease, while in the treatment with partial dentures the main reasons for tooth loss are caries and its complications (52.1%).). About 1/3 (33.3%) of the patients who were treated with total dentures lost their teeth due to carious lesions and their complications. In the treatment with partial dentures, periodontal diseases are the cause of tooth loss in 45.1% of cases.

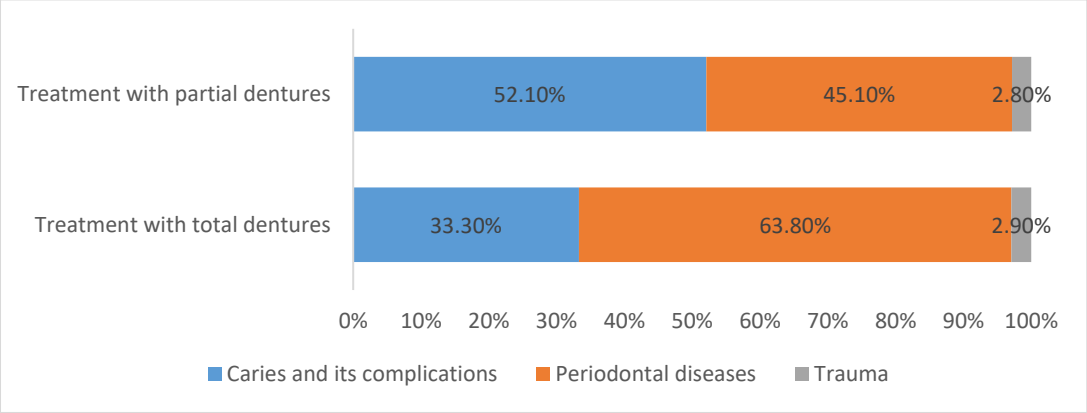

Fig. 10. Prosthetic treatment and causes of tooth loss

More than 3/4 (77.1%) of the patients who underwent prosthetic treatment with total dentures have restored both masticatory and phonetic functions, while in patients with partial dentures the recovery of both functions is restored in 48.8% of cases (p= 0.003) (Fig. 11). It is impressive that in patients with partial dentures the restoration of masticatory function (36.6%) and aesthetics (13.4%) prevail in comparison with the patients who underwent treatment with total dentures. In only 1.2% of patients with partial dentures, treatment was associated only with restoration of phonetic function.

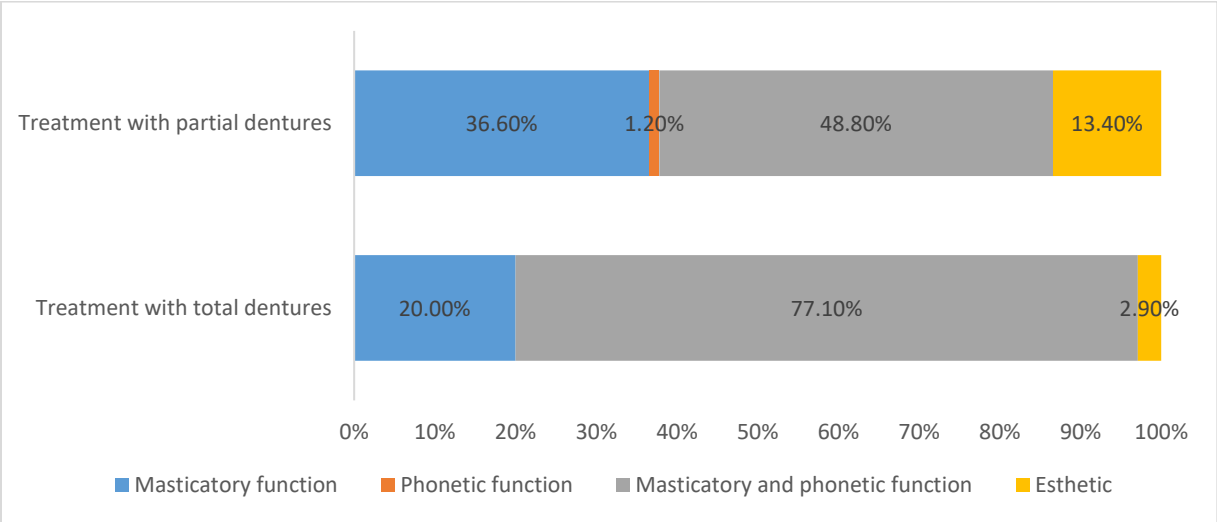

Fig. 11. Prosthetic treatment and restoration of function

Of the patients studied, only 5.9% were diagnosed with bruxism, with a predominance of women (66.7%). TMJ dysfunction was found in 27.6% of patients, mostly women (66.7%) (Fig. 12). The majority of patients with TMD are symptomatic, with a predominance of female patients (66.7%). Complaints are less common in men. Men without complaints are more than those with complaints (39.10% / 33.30%).

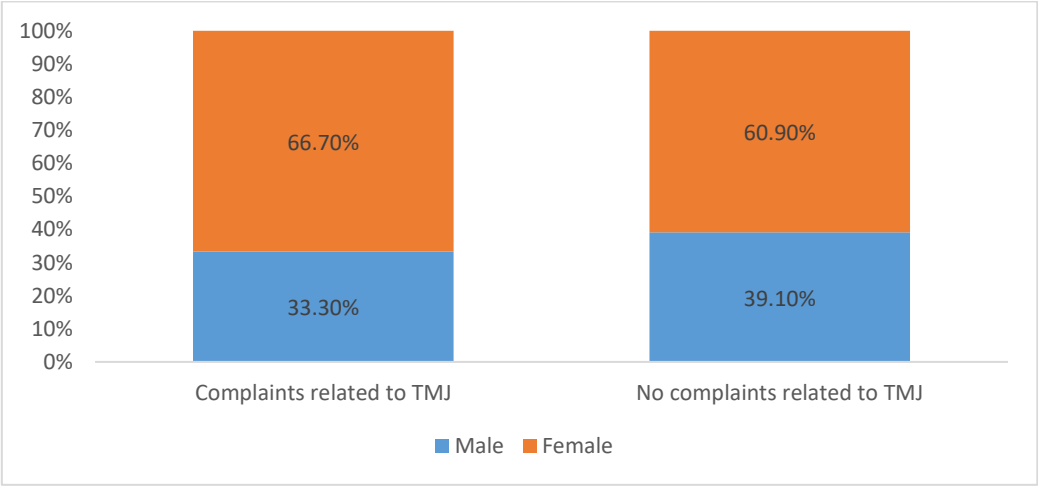

Fig. 12. Distribution of patients according to TMJ complaints and sex

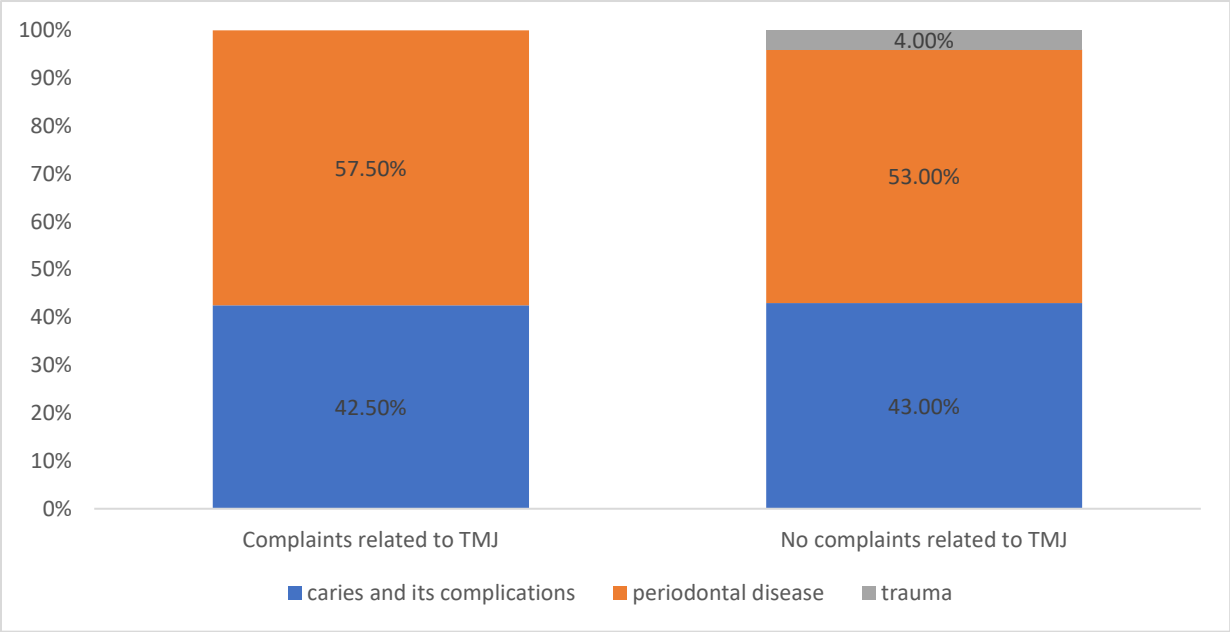

Fig. 13. Distribution of patients according to TMJ complaints and the cause of tooth loss

Persons with periodontal disease were 57.5% (Fig. 13), with recovery of both masticatory and phonetic functions - 66.7% (Fig. 14).

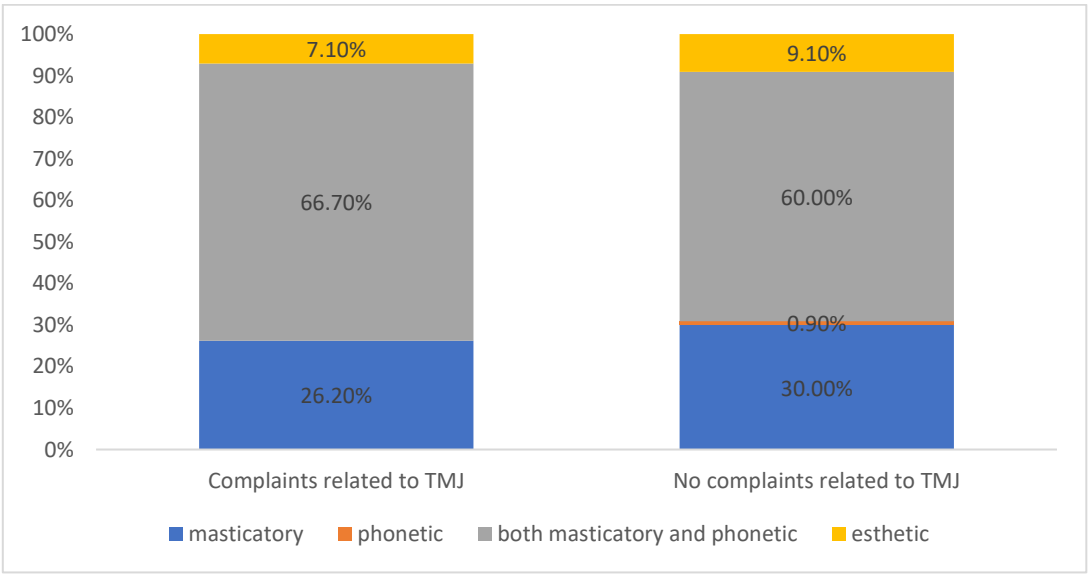

Fig. 14. Distribution of patients according to complaints related to TMJ and function

There was a significant difference in the type of dentures and complaints related to TMJ dysfunction (p = 0.030), finding that the likelihood of TMJ dysfunction in patients with total dentures increased more than twice (OR = 2.124 (1.30-4.381)); p <0.05) (Fig. 15)

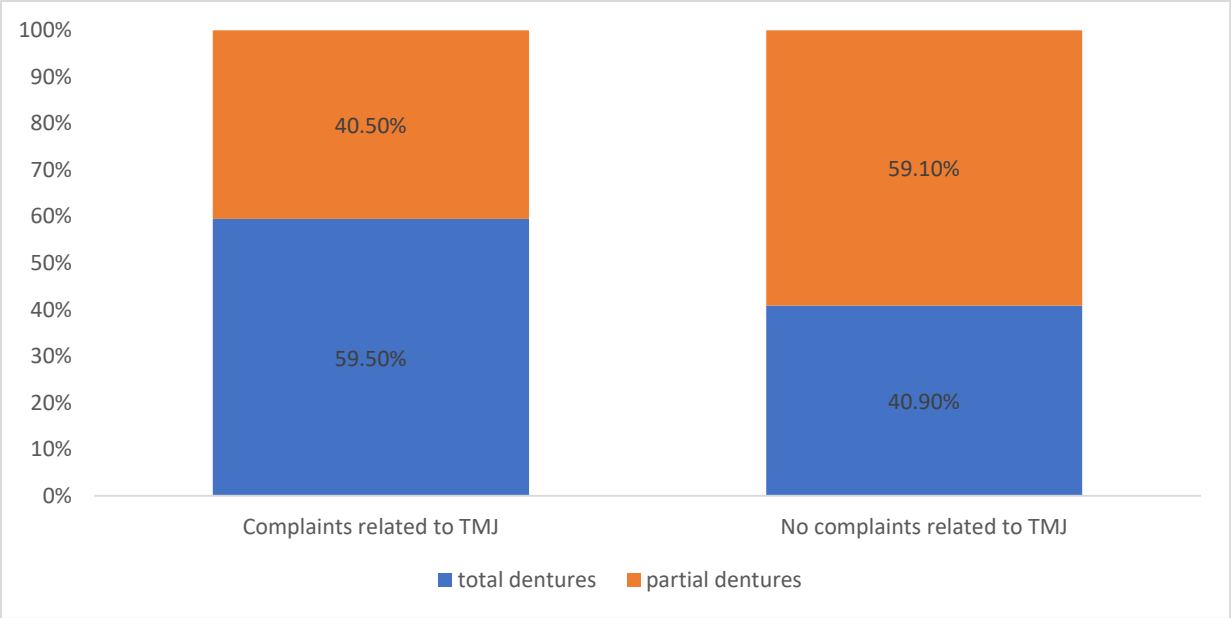

Fig. 15. Distribution of patients according to the complaints related to TMJ and the type of dentures

A directly proportional moderate correlation between bruxism and TMJ dysfunction was found (r = 0.344; p <0.001), with bruxism being responsible for 19.0% of TMJ dysfunction cases in the present study. On the other hand, bruxism is considered a risk factor for TMJ dysfunction, and its presence increases the risk of such dysfunction by about 21 times (OR = 20,952 (2,702-162,469); p <0.001) (Fig. 16), (Table 1)).

Table 1. Bruxism as a risk factor

Risk factor	OR	95 % CI	P value
Parafunction - bruxism	20.952	2.702-162.469	< 0.001

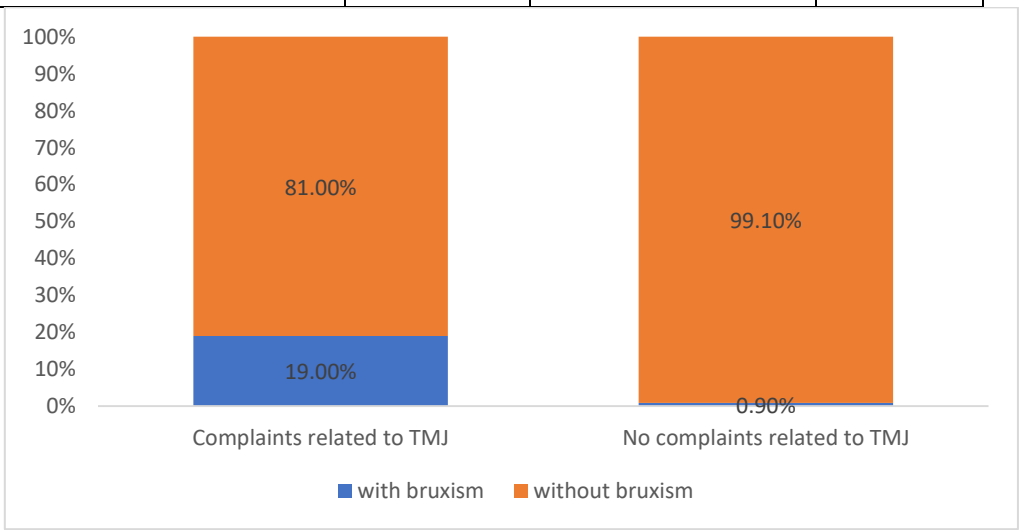

Fig. 16. Distribution of patients according to complaints related to TMJ and the presence of bruxism

11.2% of the examined patients had joint diseases, and a proportionally weak dependence with TMJ dysfunction was found (r = 0.201; p = 0.013). In the present study, joint disease was associated with 21.4% of cases of TMJ dysfunction. On the other hand, the presence of joint disease can be considered as a risk factor for TMJ dysfunction, with the risk increasing more than 3 times (OR = 3.477 (1.241-9.741); p = 0.018) (Fig. 17).

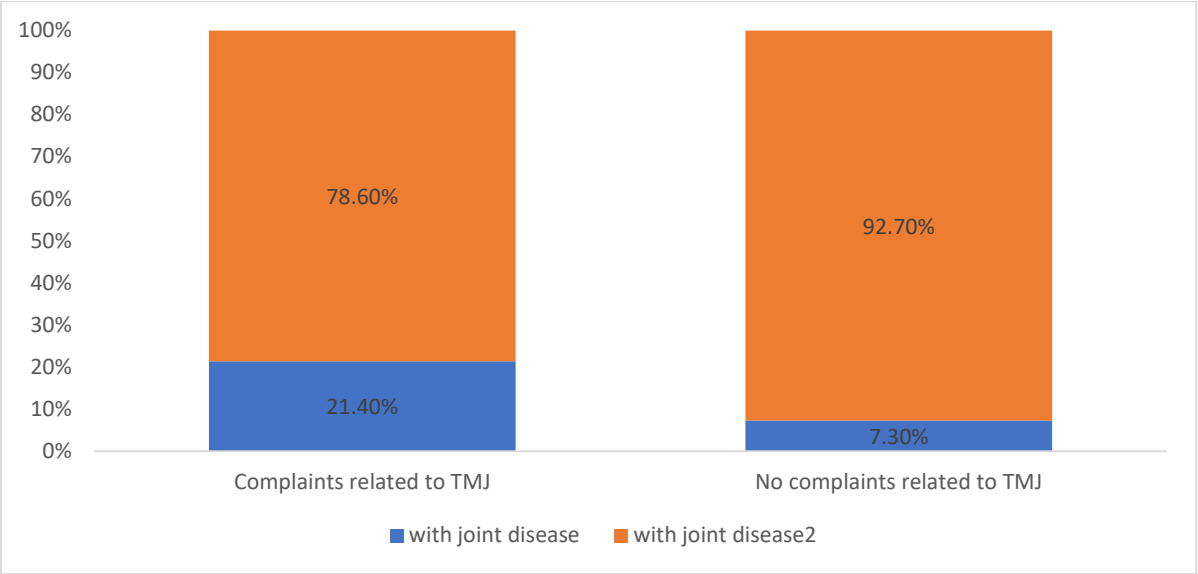

Fig. 17. Distribution of patients according to complaints related to TMJ and the presence of joint diseases

Discussion on the task:

In the present study, patients with joint disease are 11.2% of the sample, with a dependence on TMD (r = 0.201; p = 0.013). It has been found that the presence of joint disease increases the likelihood of TMJ dysfunction more than 3 times compared to patients without systemic disease. Although patients with these disorders may not have symptoms suggestive of TMJ involvement, they should be cautioned to avoid exposure to initiating risk factors, including oral parafunction and occlusal trauma.

Although age is associated with TMD according to the literature, no such correlation was found in our study (62.6 years for patients with TMD and 59.7 years for patients without TMD, respectively).

Several studies of patients with TMD showed a higher prevalence in women with a ratio of 6:1, 2:1 and 8:1, and a similar ratio is observed in our study, where 66.7% of patients with TMD are women (ratio 2:1). The reasons for the higher prevalence of TMD in women remain unclear. Some authors have linked estrogen to the development of TMD, as a higher incidence

of this pathology occurs in women in fertile age. This suggests that female sex hormones may play a role in the etiology of TMD.

Although bruxism is generally considered to be the most harmful parafunctional activity of TMJ, there are many unresolved issues regarding the actual causal relation. Many studies in this area support such a link. The lack of a specific characteristic of the two states makes this connection contradictory. The results of our study confirmed a positive correlation between bruxism and TMD ($r = 0.344$; $p < 0.001$), with the presence of parafunction such as bruxism increasing the risk of TMD by about 21 times.

To assess tinnitus of the examined patients

The mean age of patients with tinnitus is 58.5 years ± 13.5 years, with a minimum of 25 years and a maximum of 78 years. Men predominated by 65.3%, with no difference in age.

Of all 150 patients who underwent prosthetic treatment with diagnosed tinnitus, 29 also reported ear pain. Of these 29 patients, 18 reported unilateral localized pain in the left or right ear, and 7 reported acute, persistent pain lasting several hours during the day. In other patients the pain is mild, for a short period of time.

Fig. 18 shows the distribution of patients according to the type of tinnitus, with the most common being noise resembling whistling (36.4%), followed by buzzing (22.8%). On the other hand, 87 (58.0%) patients reported that tinnitus was unilateral only in the left or right ear, and in the others the noise was in both ears.

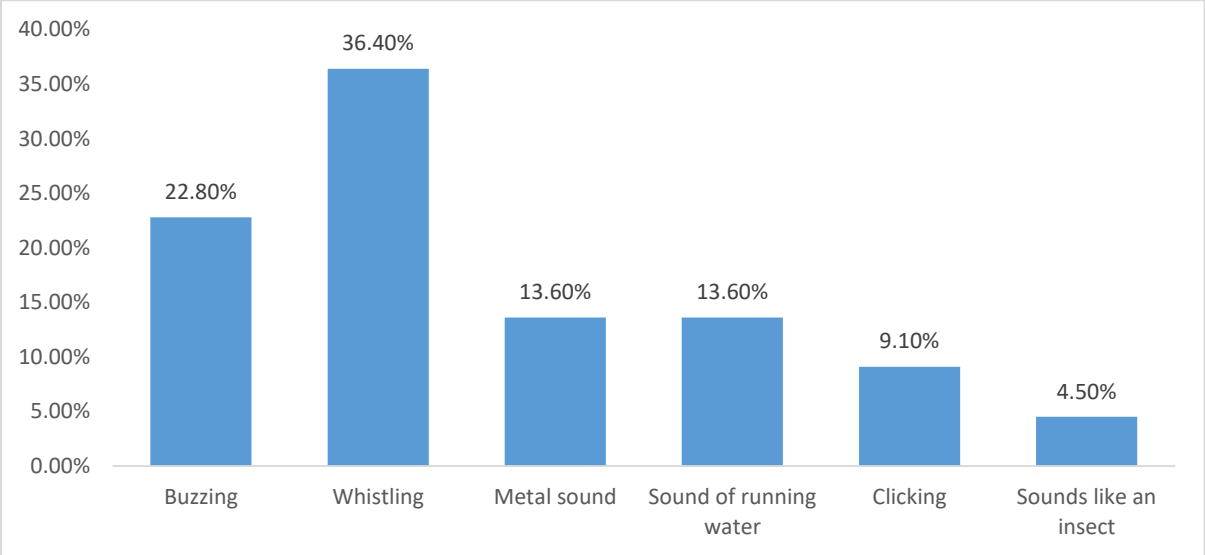

Fig. 18. Distribution according to the type of tinnitus

The average assessment of the influence of tinnitus on the daily life of the examined patients is 10.18 ± 4.34, ranging from 3.00 to 18.00 (Fig. 19). There is an almost equal distribution between the three degrees (Fig. 20).

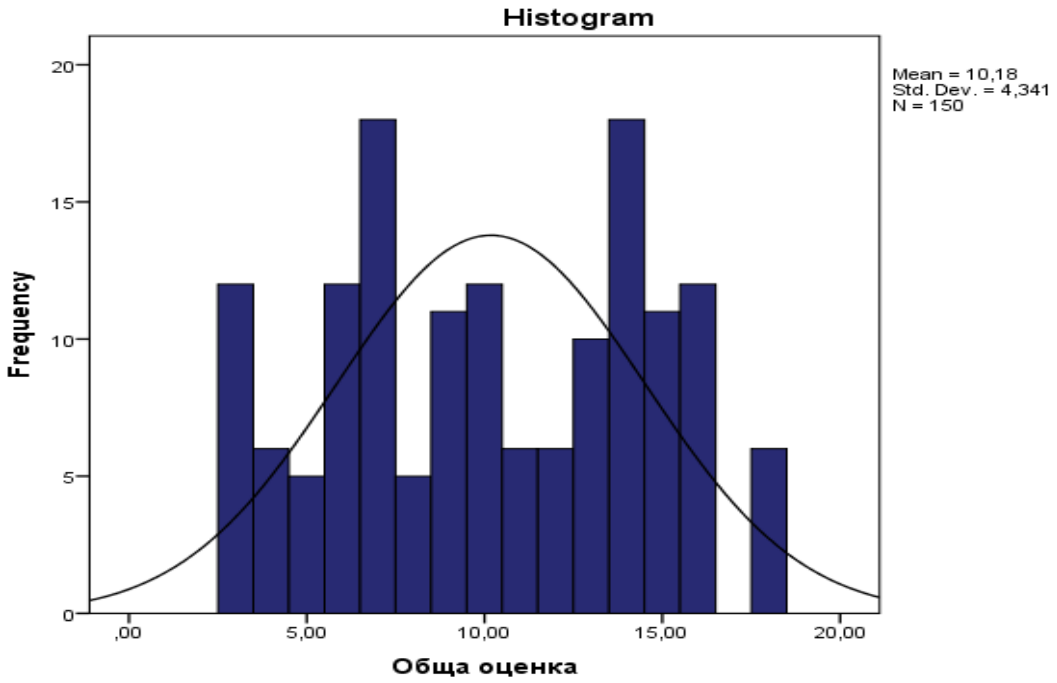

Fig. 19. Distribution of patients according to the assessment of tinnitus

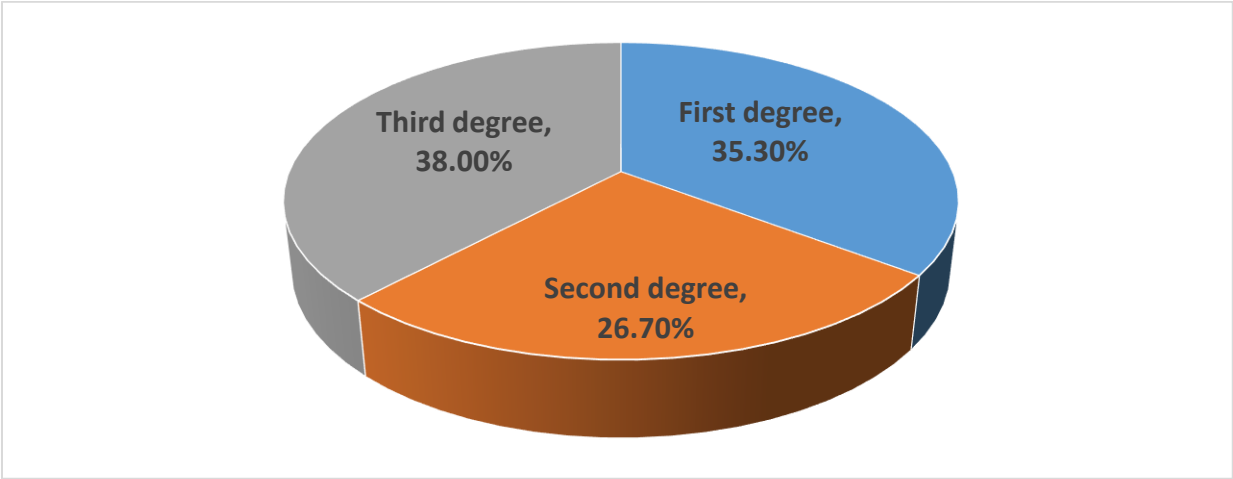

Fig. 20. Distribution of patients according to the degree of tinnitus

The reliability of the Mini TQ 12 tinnitus questionnaire was assessed according to its internal consistency and reliability in retesting. The reliability of the internal consistency for the total scale, estimated by Cronbach's α, is 0.772. The reliability of the internal sequence of the two subscales is 0.658 and 0.674, respectively, for emotional distress and cognitive distress.

Twenty percents of the participants were asked to fill in the questionnaire after 2-3 days for the reliability of the retest. The results show that the intra-class correlation coefficient is statistically significant (0.86, $p < 0.001$) (Tabl. 2 and Tabl. 3).

Tabl. 2. Mean, SD and variance of the TQ 12

Questions	Mean	SD	Item-Total Correlation
I feel the noise from waking to falling asleep	1.56	0.84	0.450
Because of the noise, I'm afraid I have a serious health problem	1.95	0.77	0.708
If the noise continues, it's not worth living	2.88	0.43	0.744
Because of the noise I am more irritable in the family and with friends	2.23	0.64	0.782
I am afraid that the noise may damage my physical health	1.95	0.76	0.664
I have a hard time resting because of the noise	2.23	0.69	0.506
Often the noise is so annoying that I can't ignore it	2.08	0.73	0.520
I find it harder to fall asleep because of the noise	1.92	0.84	0.587
I feel exhausted because of the noise	2.48	0.56	0.482
I often wonder if the noise will ever go away	1.63	0.69	0.444
I am a victim of noise	2.73	0.53	0.658
Noise affects my concentration	2.15	0.67	0.746

Tabl. 3. Correlation of individual questions with emotional and cognitive distress

Questions	Emotional distress	Cognitive distress
I feel the noise from waking to falling asleep	0.088	0.246
Because of the noise, I'm afraid I have a serious health problem	0.821	0.337
If the noise continues, it's not worth living	0.133	0.779
Because of the noise I am more irritable in the family and with friends	0.603	0.310
I am afraid that the noise may damage my physical health	0.630	-0.009
I have a hard time resting because of the noise	0.629	-0.112
Often the noise is so annoying that I can't ignore it	0.678	-0.133
I find it harder to fall asleep because of the noise	0.631	0.324
I feel exhausted because of the noise	0.435	0.102
I often wonder if the noise will ever go away	-0.045	0.734
I am a victim of noise	0.351	0.801
Noise affects my concentration	0.713	0.199

Women are more sensitive to tinnitus, with a significant difference in the average score of tinnitus between the sex (p <0.001) (Fig. 21). On the other hand, no correlation has been established between patients' age and tinnitus.

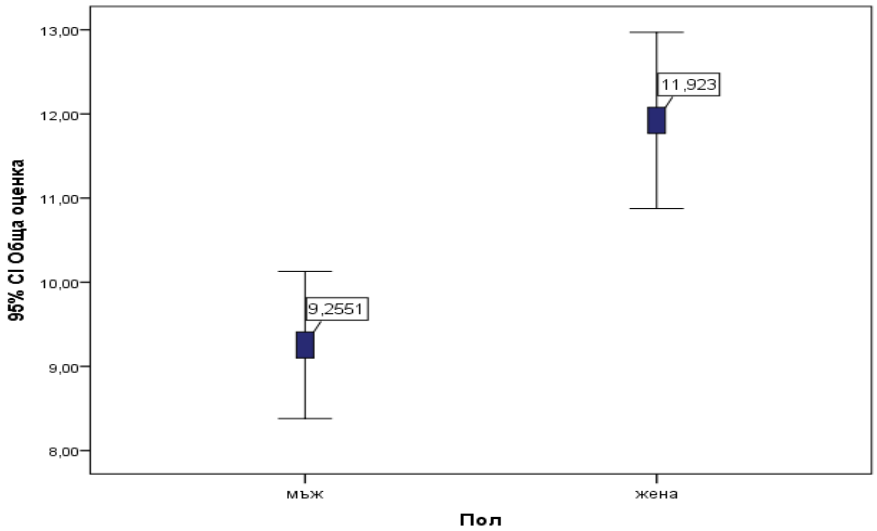

Fig. 21. Comparative analysis of the average score for tinnitus by sex

Although no significant difference was found, it can be said that patients who required prosthetic treatment had a higher score of tinnitus (p = 0.067) (Fig. 22).

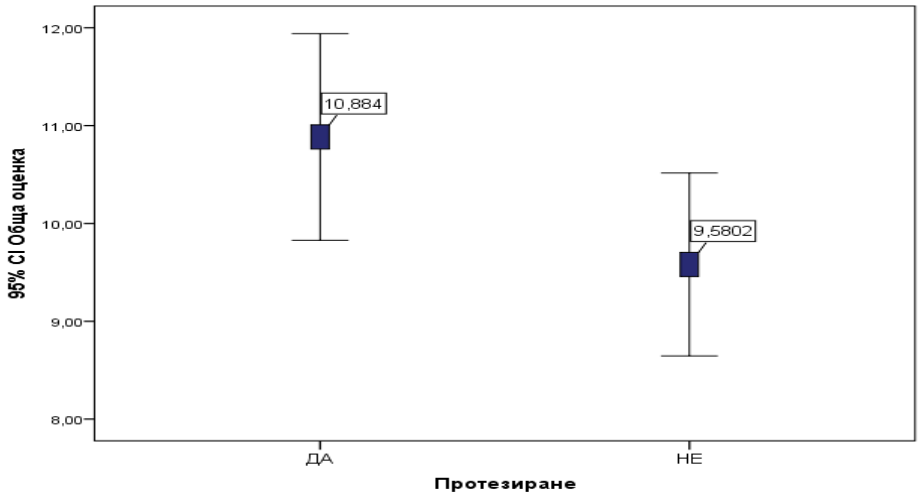

Fig. 22. Comparative analysis of the average score of tinnitus according to the need for prosthetic treatment

More than ¾ of the examined patients indicated that they felt tinnitus from the moment of waking up to falling asleep (Fig. 23), and there was no difference in the opinion of the patients according to sex and the performed prosthetic treatment.

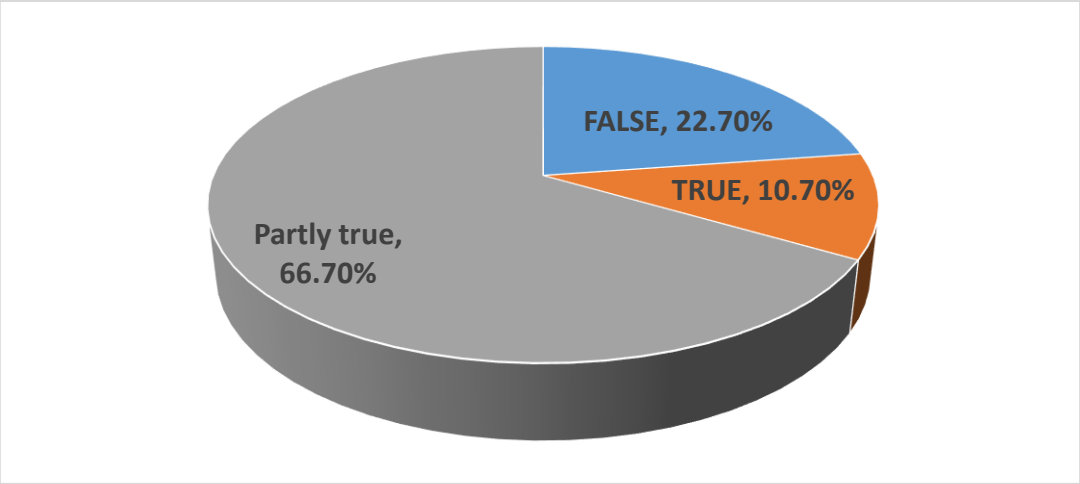

Fig. 23. I feel the noise from waking to falling asleep

A significant part of patients indicated that they feared for their health due to tinnitus (Fig. 24), finding a significant difference ($p = 0.002$) and a weak, moderate to sex dependence ($r = 0.283$; $p < 0.001$). 40.7% of the examined patients consider tinnitus to be a symptom of a serious health problem (Fig. 24).

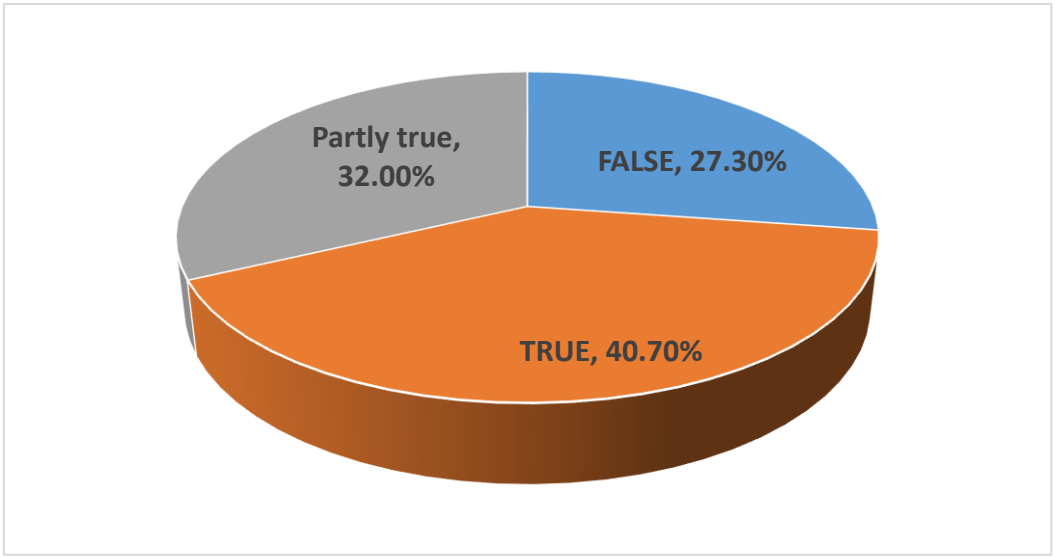

Fig. 24. Because of the noise, I'm afraid I have a serious health problem

Only 7.3% of patients reported having suicidal thoughts related to the duration of tinnitus, with no sex difference.

About 2/3 (65.3%) of the patients indicate that they are more irritable in their relations with family and friends due to tinnitus (Fig. 25).

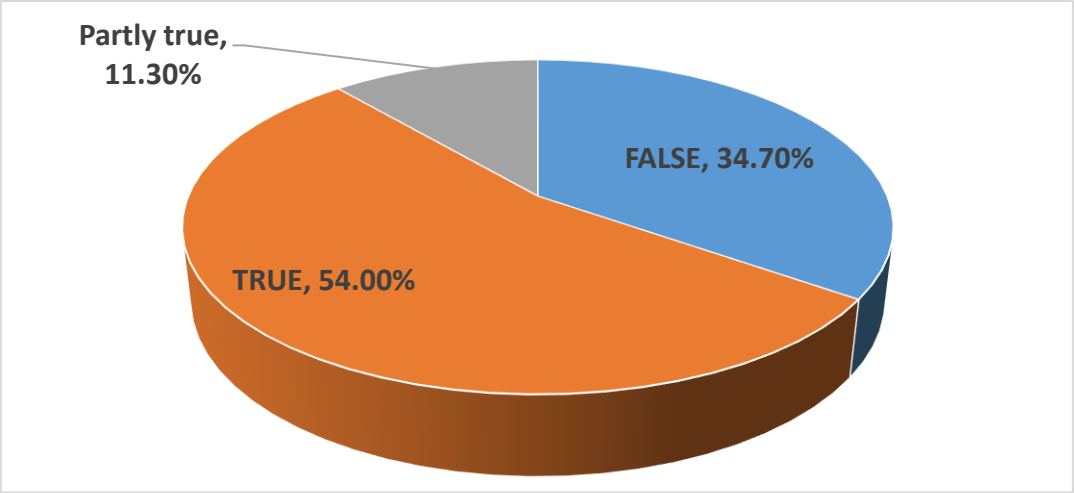

Fig. 25. Because of the noise I am more irritable in the family and with friends

There was a significant difference in tinnitus irritability between men and women (p <0.001), with this indicator moderately correlated with female gender (r = 0.380; p <0.001) (Fig. 26).

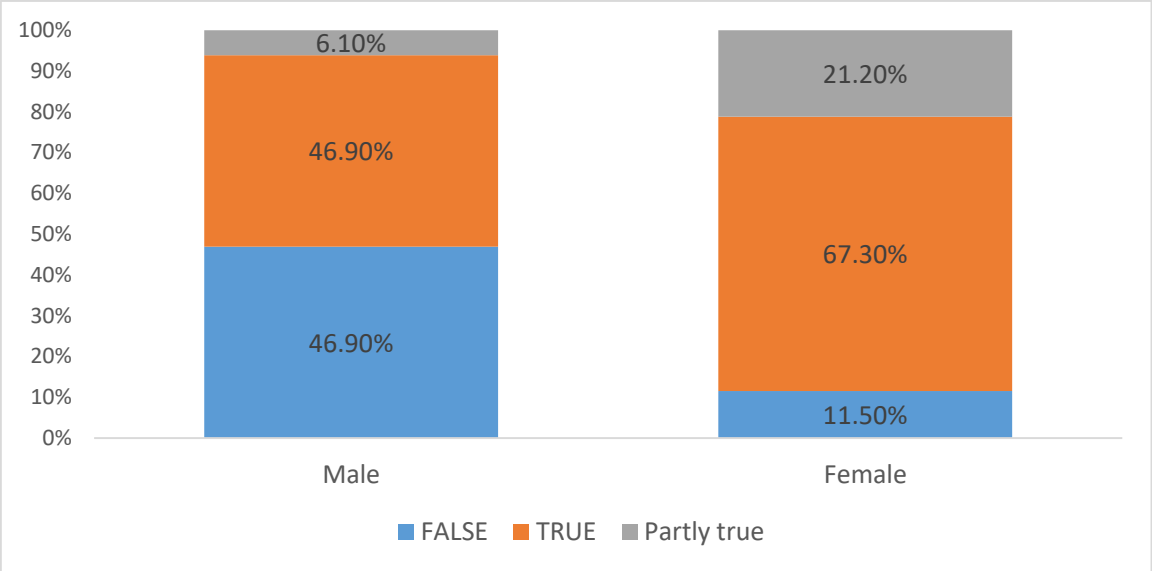

Fig. 26. Comparative analysis of patients' sex and irritability associated with tinnitus

About 3/7 (73.3%) of the surveyed patients indicated that they were afraid that the noise could harm their physical health (Fig. 27), without establishing a connection with sex and the performed prosthetic treatment.

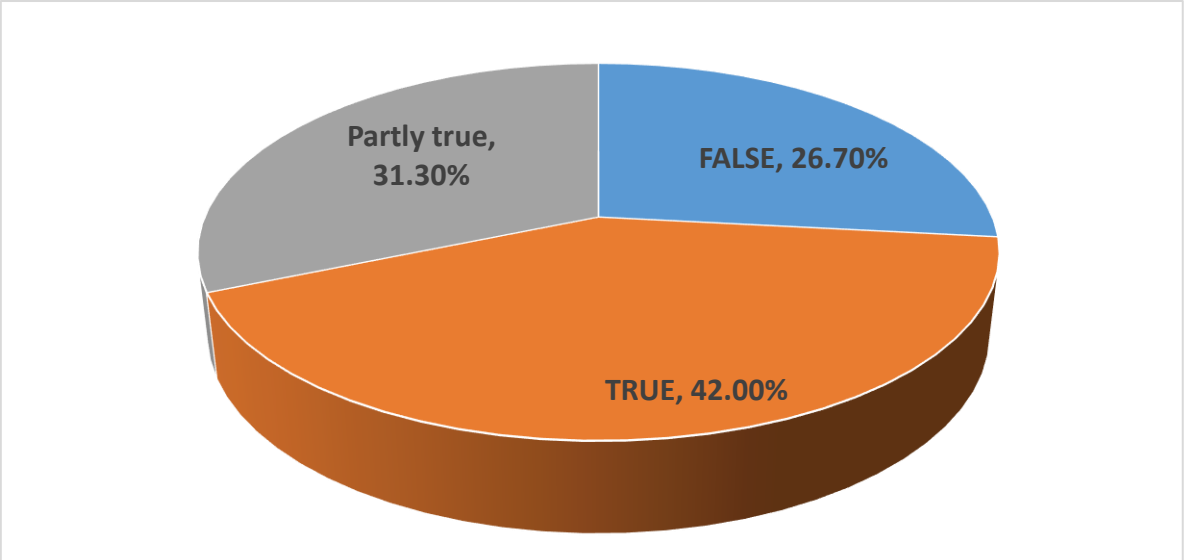

Fig. 27. I am afraid that the noise may damage my physical health

Only 22.7% are considered victims of tinnitus, with no difference according to sex, and in more than 2/3 (68.7%) of the studied patients the noise affects their concentration (Fig. 28). The concentration of women was significantly more affected by tinnitus than the concentration in men (88.5% for women and 58.2% for men, respectively; p <0.001) (Fig. 29).

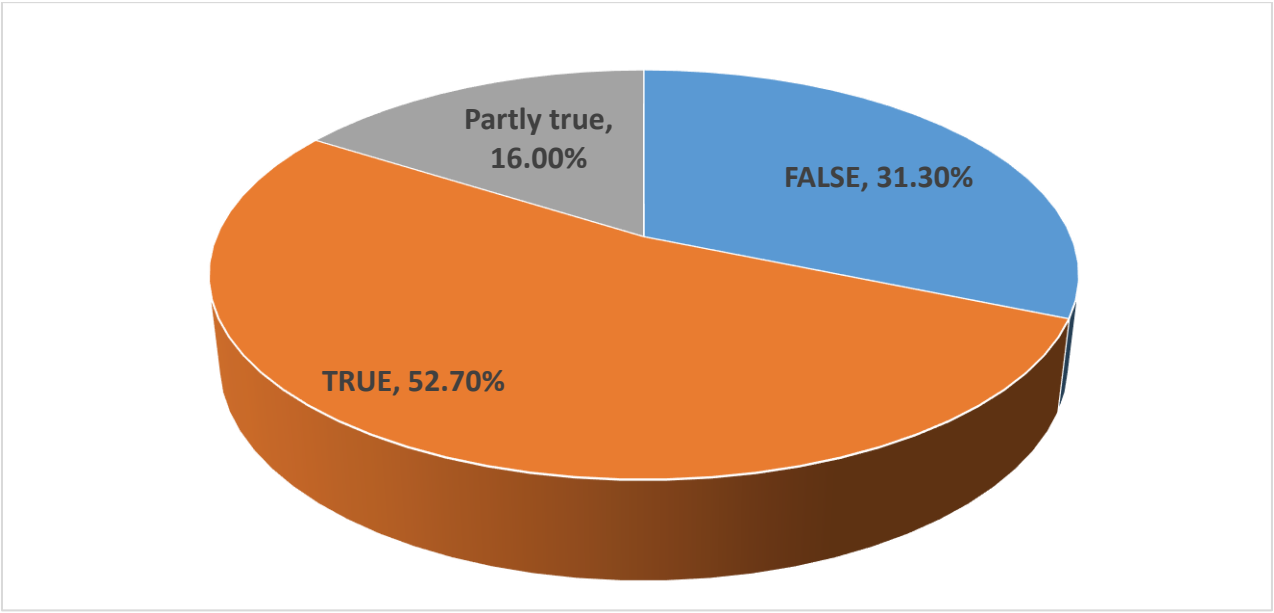

Fig. 28. Noise affects my concentration

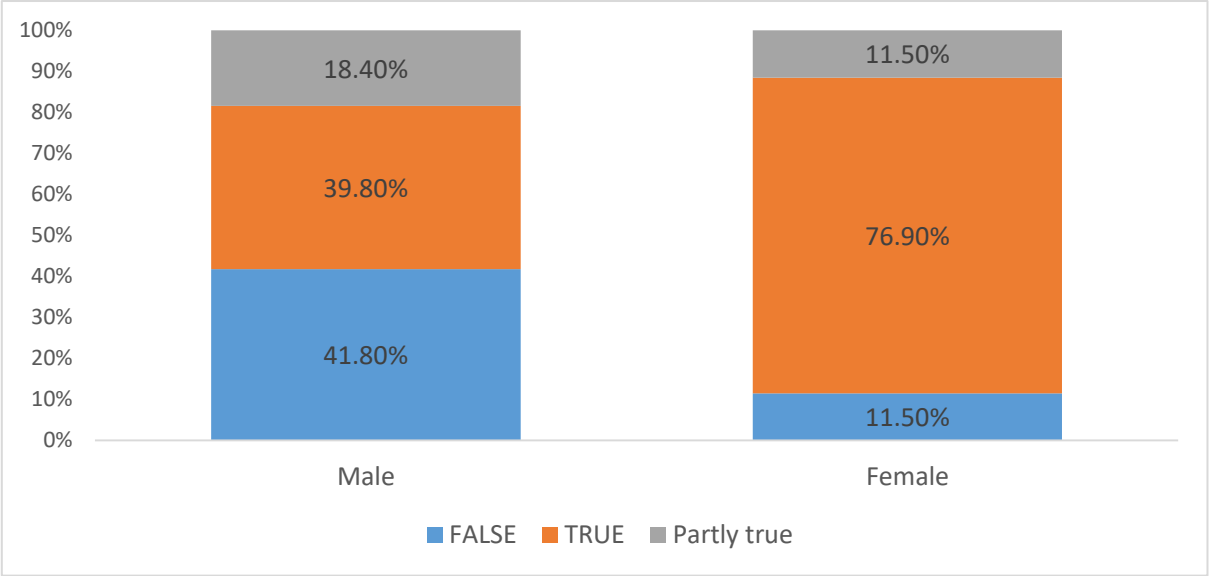

Fig. 29. Comparative analysis of patients' opinions according to sex and concentration problems due to tinnitus

Discussion on the task:

According to the literature, the general phylogenetic and ontogenetic development of the masticatory muscles, facial muscles and ear muscles originating from the first pharyngeal arches is not insignificant for the accompanying otolaryngological symptoms in TMJ dysfunction.

In addition, posterior dislocation of the head of the lower jaw due to lack of teeth, pathological tooth wear or trauma can compress the tympanic artery and vein, leading to circulatory disorders in the middle ear and this complex plays role as a risk factor for hearing loss. At the same time, compression of the joint head can damage the tympanic ligament, leading to contracture of the m. stapedius by a reflex mechanism transmitted through the facial nerve. The course of the auriculotemporal nerve in the area of the temporomandibular joint helps to compress it from the mandibular joint, generating an impulse for reflex contracture of the tympanic tensor muscle, leading to hearing damage or symptoms of tinnitus.

Mini-TQ is easy and quick to apply and also has good psychometric properties. The average overall score of the Mini-TQ was 10.18 ± 4.34 (3.00 - 18.00). So far, average results have been found from 7.95 ± 5.57 (Greek version) to 15.4 ± 5.7 (German version). Our results can be considered compatible with the literature. A number of authors have confirmed the violation of the quality of life in patients with tinnitus.

Acoustic symptoms such as popping or clicking sounds may also be present, as evidenced by a lack of coordination between the articular head and the articular discs during movement of the lower jaw.

In clinical practice, other symptoms of TMJ dysfunction may be identified, which are associated with ophthalmic disorders and dysfunction in the muscles of the neck and shoulders, back muscles, and chest muscles. In these cases, the differential diagnosis is the key element in the treatment process.

To investigate TMJ dysfunction

28.7% of the studied patients with tinnitus were diagnosed with TMJ dysfunction. Fig. 30 presents the main complaints of patients that may be associated with TMJ dysfunction. The most common are pain during speech (16.00%), followed by clicking of the TMJ (15.3%) and pain during chewing (14.00%).

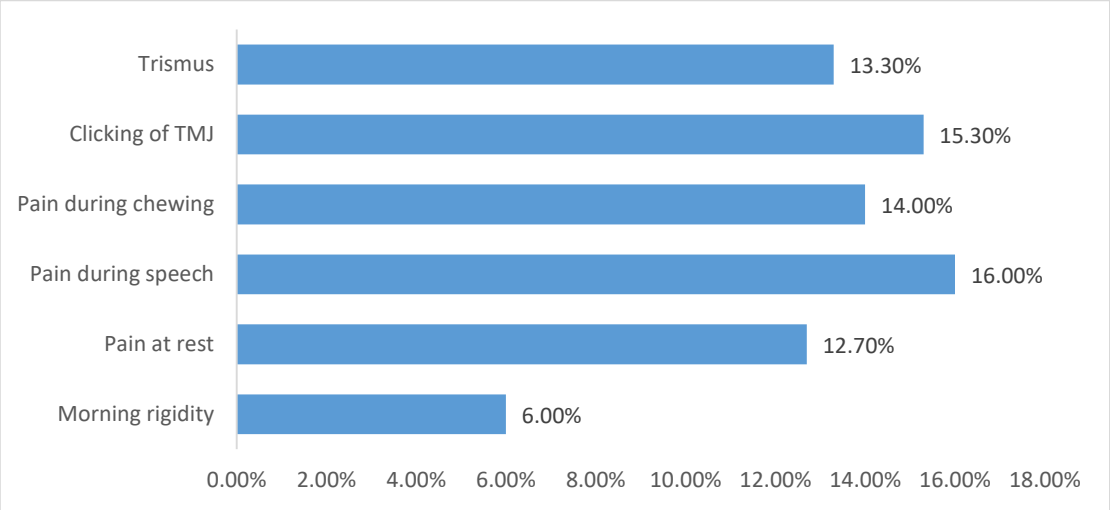

Fig. 30. Main complaints of patients

A significant difference in sex was found with regard to the clicking of the TMJ, which was more frequent in women (10.2% for men and 25.0% for women, respectively; $p = 0.017$).

The other difference was found for pain at rest ($p = 0.047$), where 19.2% of women and 9.2% of men had similar complaints.

For the other complaints, there was a variation in the frequency, but without significant differences between men and women (Fig. 31).

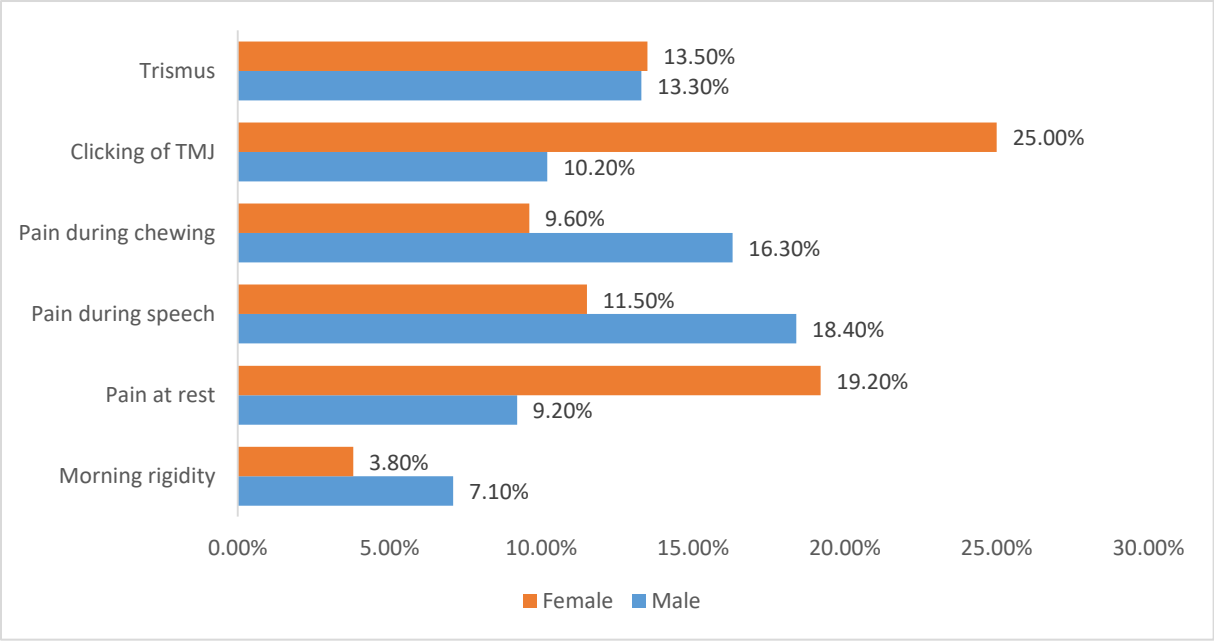

Fig. 31. Main complaints of patients by sex

A comparative analysis of the occurrence of complaints in patients in need of prosthetic treatment and those who do not need it because they do not have missing teeth or are prosthetically rehabilitated, found that there is a significant difference in several factors (Fig. 32). Patients with such a need are all with partial or complete edentulousness.

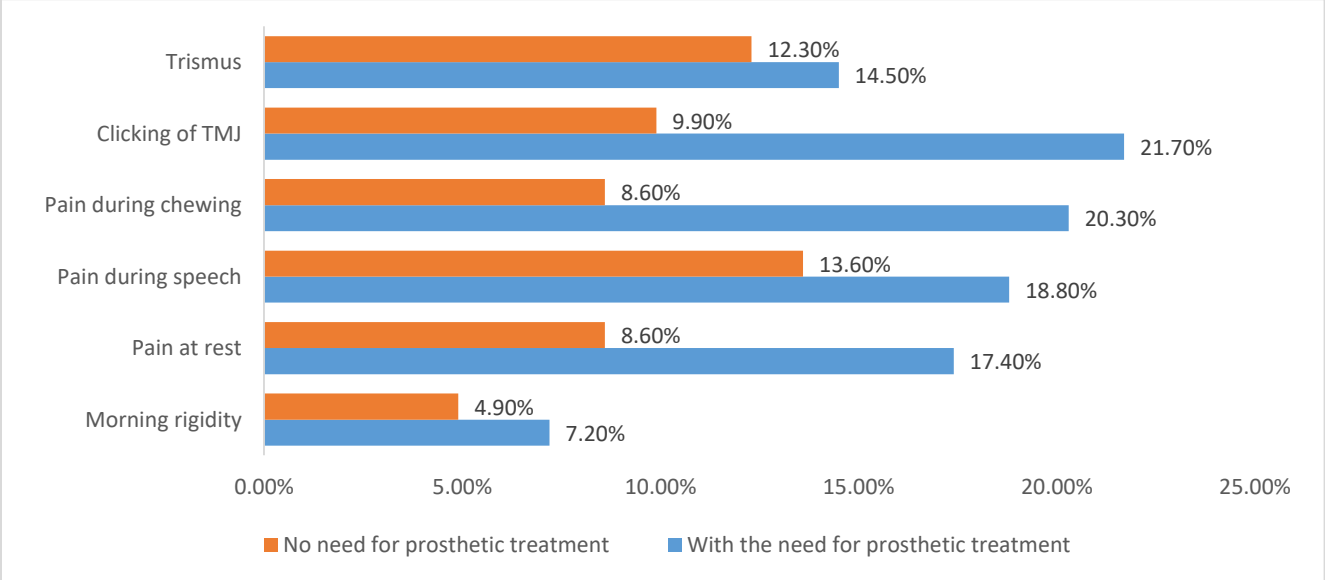

Fig. 32. Main complaints of the patients according to the performed prosthetic treatment

The number of patients who began to experience pain at rest in need of prosthetic treatment was significantly higher (17.4% versus 8.6%; p = 0.037). It was found that the lack

of prosthetic treatment in patients in need of such leads to an increase in the risk of pain at rest by 2.23 times (OR = 2.23 (0.824-6.014); p <0.05).

A significant difference was also found for pain during chewing (p = 0.035). In patients in need of prosthetic treatment, it is more common (20.3% to 8.6%). Prosthetically untreated patients were found to be 2.69 times higher at risk of pain during chewing (OR = 2.69 (1.018-7.113); p <0.05).

The clicking of the TMJ is another factor that is influenced by the prosthetic treatment, as its frequency is 21.7% among the patients who did not receive treatment, but needed it. The incidence was 9.9% in those treated (p = 0.037). The lack of prosthetic treatment was found to increase the risk of TMJ clicking by 2.54 times (OR = 2.54 (1.003-6.407); p <0.05).

Fig. 33 presents the results of the study of pain on palpation of five points in the area of TMJ.

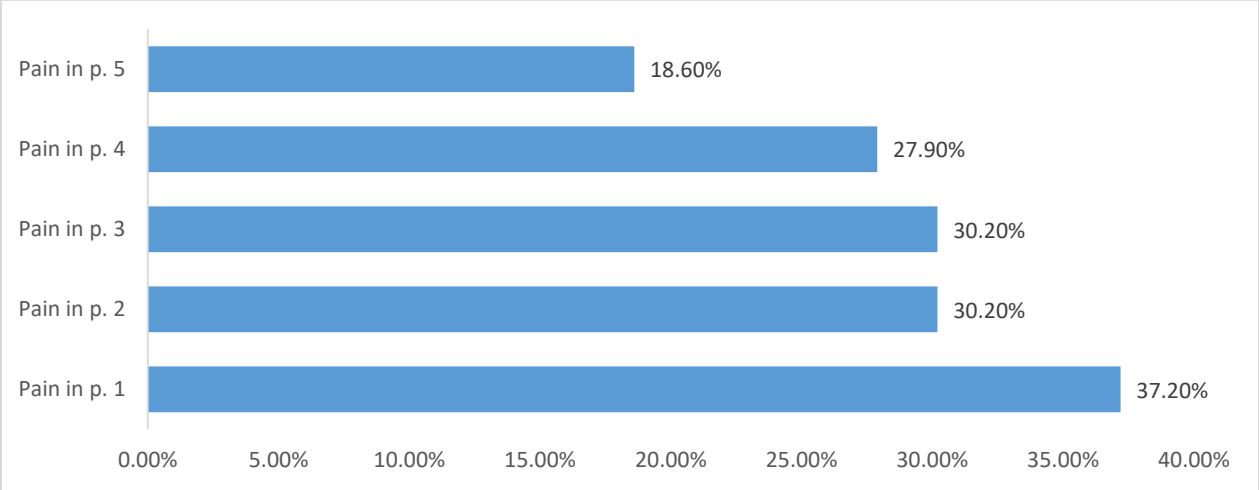

Fig. 33. Frequency of pain at the points of palpation

The analysis of the pain in the examined points according to sex and the performed prosthetic treatment did not reveal a significant difference.

The majority of patients who complained of morning rigidity experienced pain at the study points (p = 0.001) (Fig. 34).

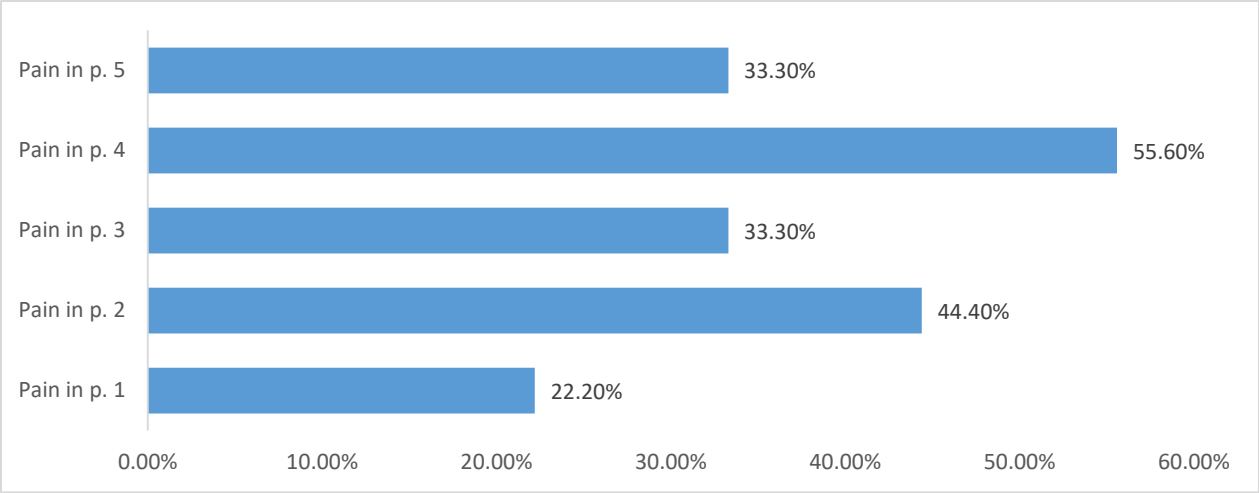

Fig. 34. Frequency of pain at the study points in patients with morning rigidity

In patients who report morning rigidity in the temporomandibular joint, pain is reported on palpation, mostly in p. 4, followed by p. 2.

The pain in p. 4 is associated with compression of the TMJ as a result of night clenching of teeth in patients with bruxism and bruxomania.

The pain in p. 2 is indicative of increased tonus of the m.pterygoideus lateralis, which is activated by parafunctional movements in the temporomandibular joint.

Pain at rest is associated with pain on palpation of points 1 to 4 ($p < 0.001$) (Fig. 35).

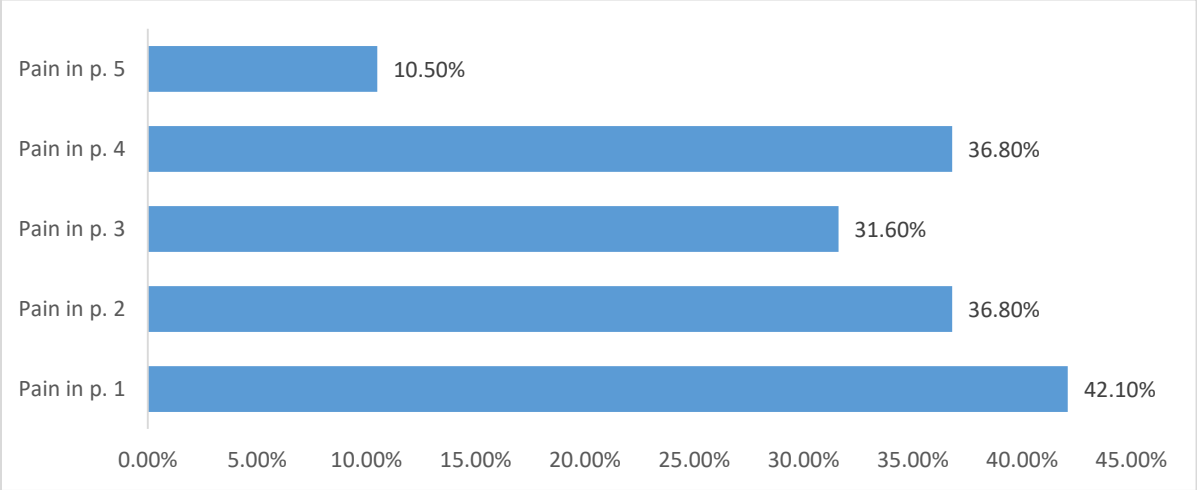

Fig. 35. Frequency of pain at the examined points in patients with pain at rest

The majority of patients who complained of pain during speech experienced pain at the examined points ($p < 0.01$) (Fig. 36). Here the results are approximate, because they are based on subjective data obtained from the patient, who points out with his finger at the painful points during speech.

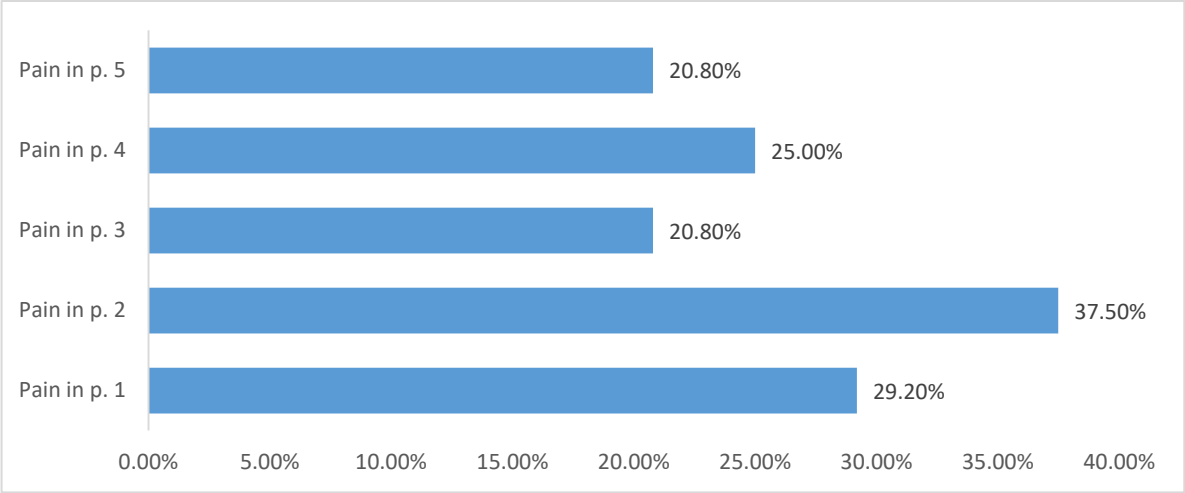

Fig. 36. Frequency of pain at the examined points in patients with pain during speech by subjective criteria

Pain during chewing was associated with pain in points 1 to 3, according to patient data ($p < 0.01$) (Fig. 37).

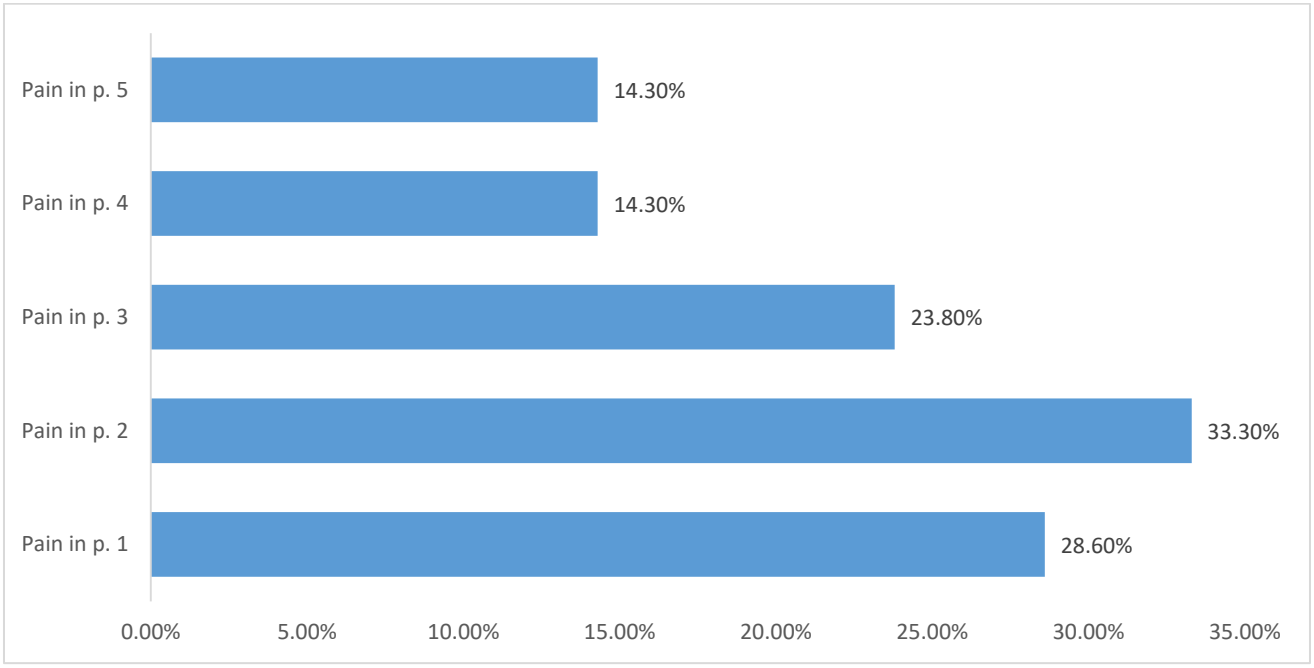

Fig. 37. Frequency of pain at the examined points in patients with pain during chewing

The clicking of the TMJ is related to pain on palpation at points 1 to 4 ($p < 0.01$) (Fig. 38). In the largest percentage of patients the pain is in p. 3 and p. 2.

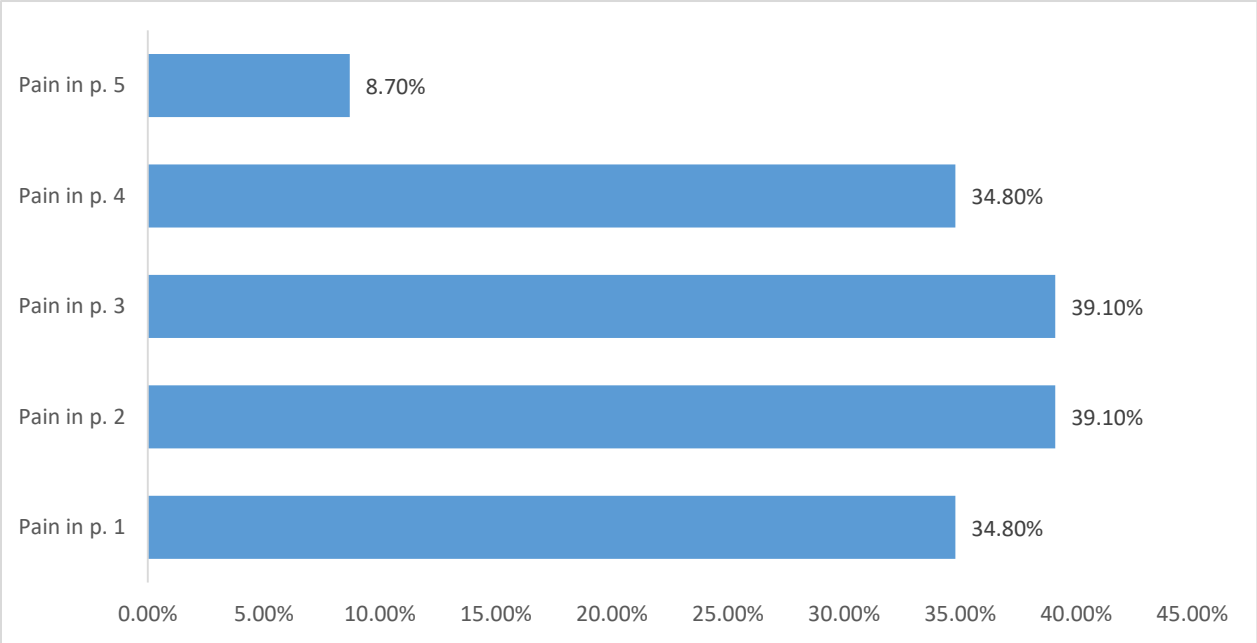

Fig. 38. Frequency of pain at the examined points in patients with TMJ clicking

These results direct the clinician to hypermobility of the articular disc in the joint, which is associated with its dislocation by repositioning. The majority of patients with trismus experienced pain at the examined points ($p < 0.01$) (Fig. 39).

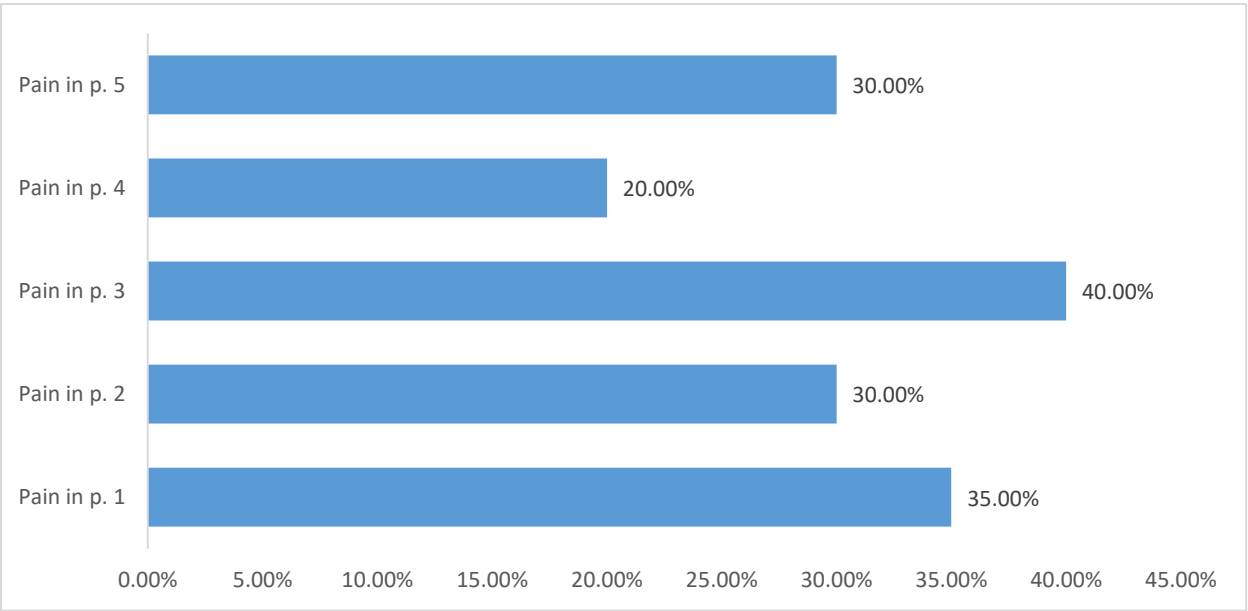

Fig. 39. Frequency of pain at the examined points in patients with trismus

On the table. 4 presents a correlation analysis between the main complaints reported by the patient (subjective criteria) and the pain diagnosed by palpation at the examined points (objective criteria).

Table 4. Correlation analysis between the main complaints and the pain in the examined points

Main complaints	Pain in p. 1	Pain in p. 2	Pain in p. 3	Pain in p. 4	Pain in p. 5
Morning rigidity	R=0.367 p<0.001	R=0.339 P=0.138	R=0.222 P=0.006	R=0.367 P=0.002	R=0.315 P<0.001
Pain at rest	R=0.388 p<0.001	R=0.381 P<0.001	R=0.310 P<0.001	R=0.405 P<0.001	R=0.088 P=0.284
Pain during speech	R=0.262 P=0.001	R=0.447 P<0.001	R=0.189 P=0.021	R=0.273 P=0.001	R=0.301 P<0.001
Pain during chewing	R=0.234 P=0.004	R=0.354 P<0.001	R=0.217 P=0.008	R=0.093 P=0.255	R=0.161 P=0.049
Clicking of the TMJ	R=0.332 p<0.001	R=0.461 P<0.001	R=0.461 P<0.001	R=0.420 P<0.001	R=0.064 P=0.439
Trismus	R=0.309 p<0.001	R=0.297 P<0.001	R=0.437 P<0.001	R=0.173 P=0.034	R=0.431 P<0.001

Morning rigidity correlates most strongly with pain in point 4 (0.367), followed by pain in point 2 (0.339).

Pain at rest shows the strongest correlation with pain in point 4 (0.405), followed by pain in point 1 (0.388) and point 2 (0.381).

Pain during speech has the strongest relation with pain in point 2 (0.447), followed by that in point 5 (0.301).

The pain during chewing correlates mainly with the pain in point 2 (0.354).

The clicking of the TMJ correlates with almost all points except for point 5, as in point 2 and point 3 the dependence is the strongest (0.461).

Trismus shows a strong dependence on pain in point 3 (0.437) and point 5 (0.431).

On the table. 5 is presented a risk model of the correlation between subjective and objective criteria for TMD.

Table 5. Odds ratio (OR) according to the main complaints and pain in the examined points

Main complaints	Pain in p. 1	Pain in p. 2	Pain in p. 3	Pain in p. 4	Pain in p. 5
Morning rigidity	14.77 (3.46-63.08	3.38 (0.62-18.26)	6.55 (1.42-30.18)	13.30 (2.98-59.36)	13.60 (2.62-70.70)
Pain at rest	11.18 (3.51-35.59)	12.15 (3.51-42.03)	8.17 (2.38-28.00)	14.70 (4.04-53.47)	2.45 (0.45-13.13)
Pain during speech	5.35 (1.76-16.26)	18.30 (5,02-66.76)	3.88 (1.15-13.12)	6.67 (1.94-22.93)	10.79 (2.38-48.87)
Pain during chewing	4.76 (1.51-14.97)	10.25 (3.02-34.81)	4.73 (1.38-16.22)	2.22 (0.55-8.98)	4.13 (0.91-18.79)
Clicking of the TMJ	7.93 (2.59-24.25)	19.77 (5.38-72.62)	19.77 (5.38-72.62)	16.40 (4.41-61.06)	1.92 (0.36-10.16)
Trismus	7.24 (2.31-22.67)	7.54 (2.22-25.57)	16.67 (4.71-59.03)	3.81 (1.03-14.11)	27.43 (5.05-149.06)

Discussion on the task:

Temporomandibular dysfunction is a general term that encompasses a heterogeneous group of musculoskeletal and psychophysiological pain conditions involving the temporomandibular joint (TMJ) and adjacent structures. The predominant clinical signs include pain, tenderness on palpation, limited range of motion, and clicking sounds.

Temporomandibular joint pain is relatively common, affecting about 15% of women and 8% of men. In our study, pain at rest affects 12.7% of the subjects, pain during chewing - 14.0%, and pain during speech - 16.0%. Pain at rest is more pronounced in women (52.6%), while pain during chewing and pain during speech is more pronounced in men (76.2% and 75.0%, respectively).

To investigate and evaluate the correlation between tinnitus and TMJ dysfunction

The analysis of the correlation between TMJ dysfunction and the degree of severity of tinnitus found that there was no significant difference between patients with and without TMD (Fig. 40), and no significant difference was found according to the sex of the studied patients and prosthetic treatment.

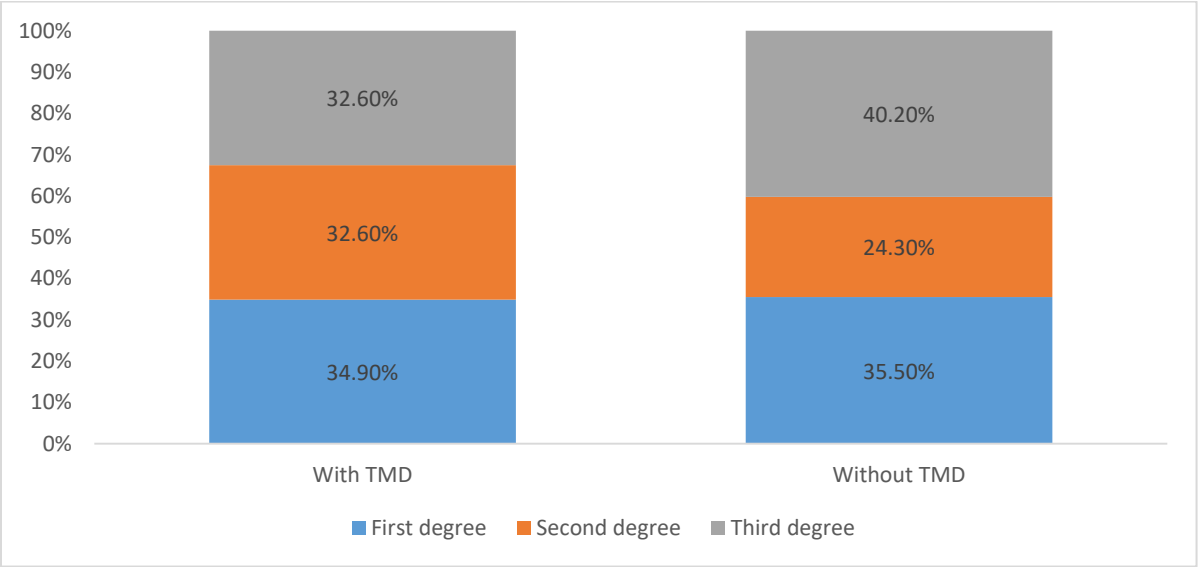

Fig. 40. TMJ dysfunction and severity of tinnitus

There was no significant difference in the severity of tinnitus according to the pain found in point 1. (Fig. 41), which is not affected by sex and prosthetic treatment of patients.

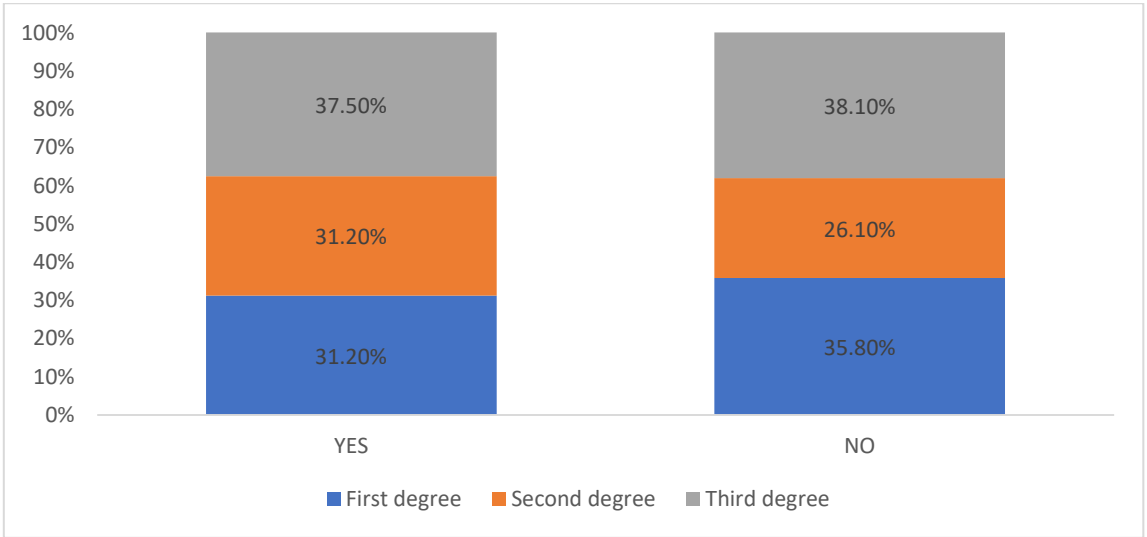

Fig. 41. Degree of severity of tinnitus and pain in point 1

Figure 42 presents a comparative analysis of the severity of tinnitus according to the pain found on palpation of the area in point 2. The results show a significant difference (p = 0.014), which shows that when pain is detected in point 2 prevails first and second degree of severity of tinnitus (46.2% and 38.5%, respectively).

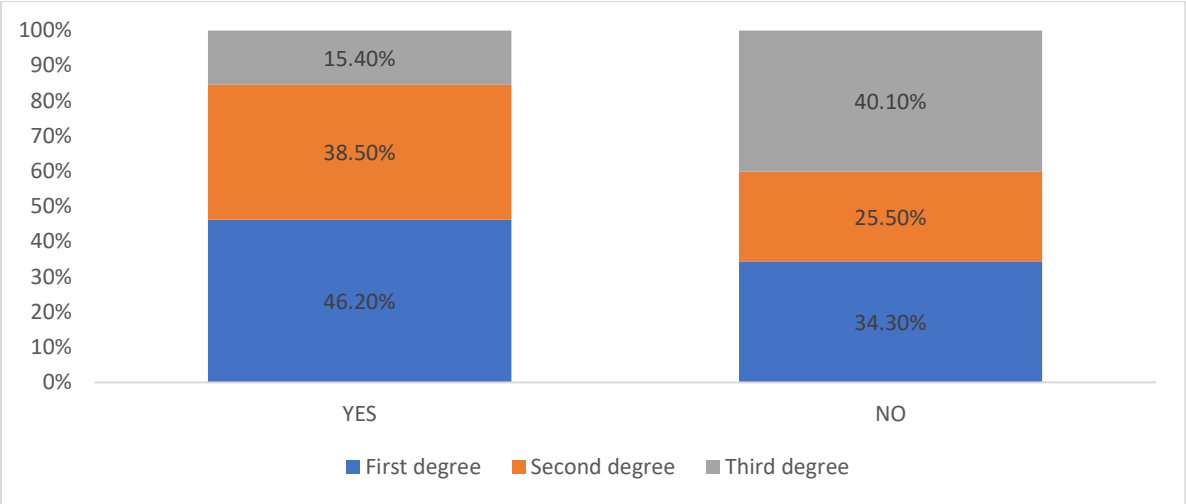

Fig. 42. Degree of severity of tinnitus and pain in point 2

The difference with the severity of tinnitus was also found with regard to the pain in point 3 (p = 0.016), as in patients with pain in point 2 those with second degree tinnitus prevailed (respectively 46.2% to 24.8%) (Fig. 43). No dependence on sex and prosthetic treatment was found.

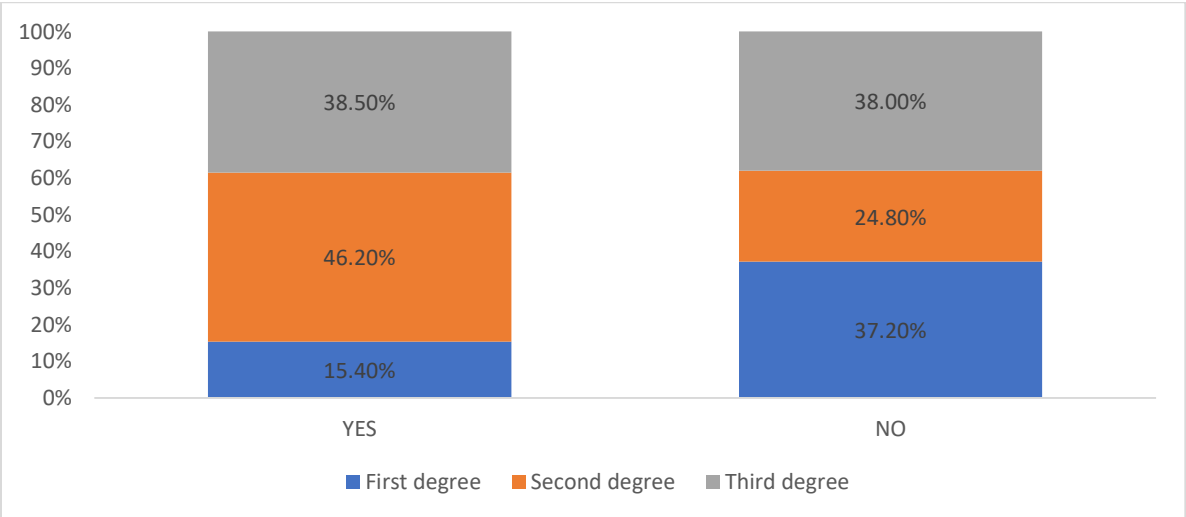

Fig. 43. Degree of severity of tinnitus and pain in point 3

There was a significant difference between the severity of tinnitus in pain found in point 4 (p = 0.047), with a predominance of patients with third degree (41.7% to 37.7%) (Fig. 44). The third degree of severity of tinnitus correlates with the pain found in point 4 (r = 0.238; p = 0.020). No connection with sex and prosthetic treatment was found.

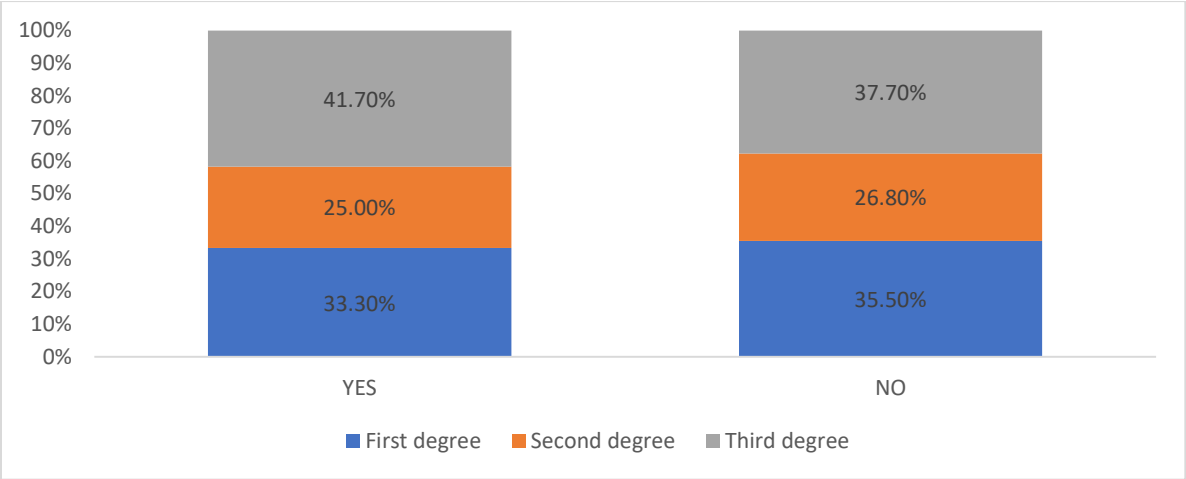

Fig. 44. Degree of severity of tinnitus and pain in point 4

Half of the patients with established pain in point 5 have the first degree of severity of tinnitus, with a significant difference between the studied groups (p = 0.034) (Fig. 45). There is a correlation between sex and the severity of tinnitus in pain found in point 5, as the third degree correlates with sex (r = 0.351; p = 0.035), while the first degree is more typical for men (Fig. 46)

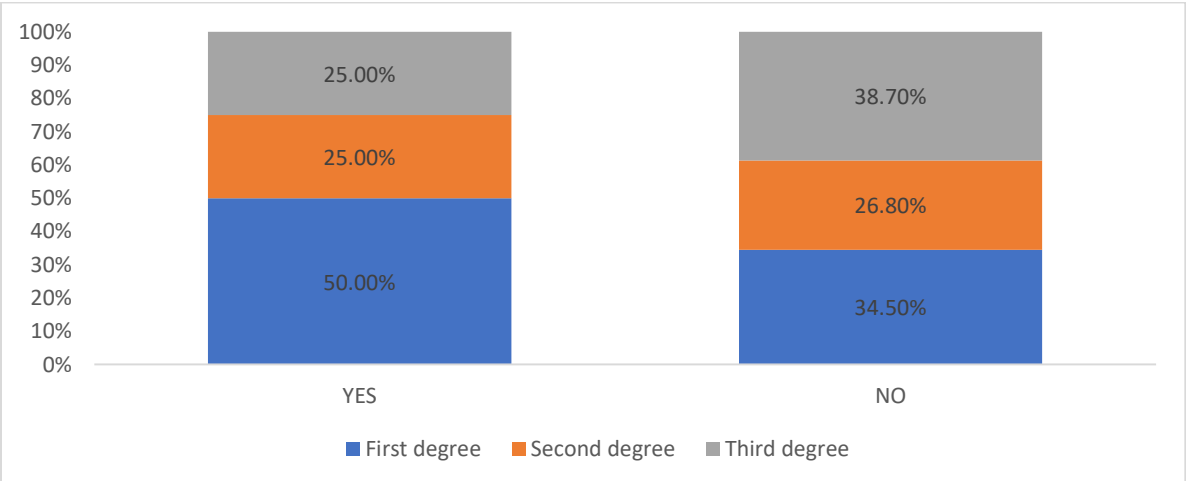

Fig. 45. Degree of severity of tinnitus and pain in point 5

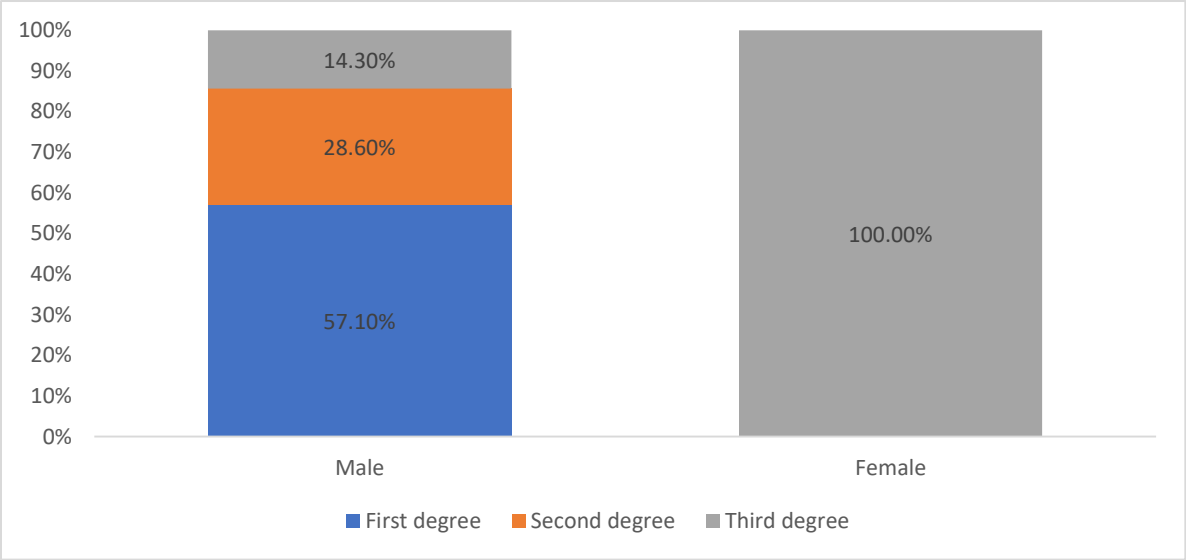

Fig. 46. Degree of severity of tinnitus and pain in point 5 according to sex

All patients who underwent a tympanogram showed normal results in the right ear, with mean values of -31.7 daPa ± 32.7 daPa (from -143.0 daPa to 7.0 daPa), and in 6 patients a deviation from the norm above -150 daPa in the left ear, with an mean value of -35.0 daPa ± 39.8 daPa (-152.0 daPa to -6.0 daPa) (Fig. 47).

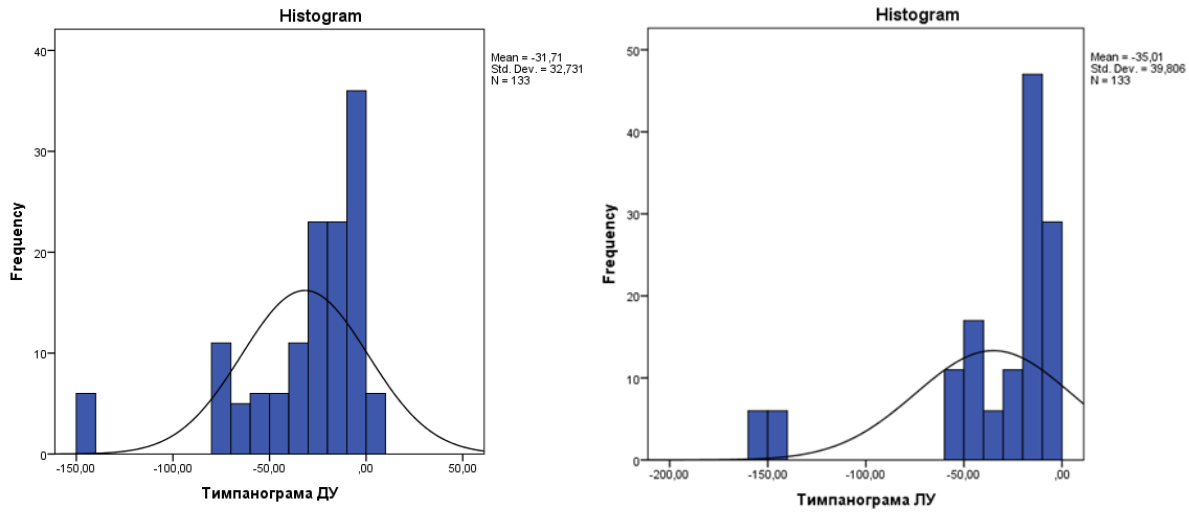

Fig. 47. Mean values of the tympanogram of the right and left ear

The results illustrated in Fig. 48, show that the values of the audiogram are higher in patients with TMD (60.37 for the right ear and 61.11 for the left ear compared to 57.25 for the right and 58.20 for the left ear, respectively), although the difference is not statistically significant (Fig. 48).

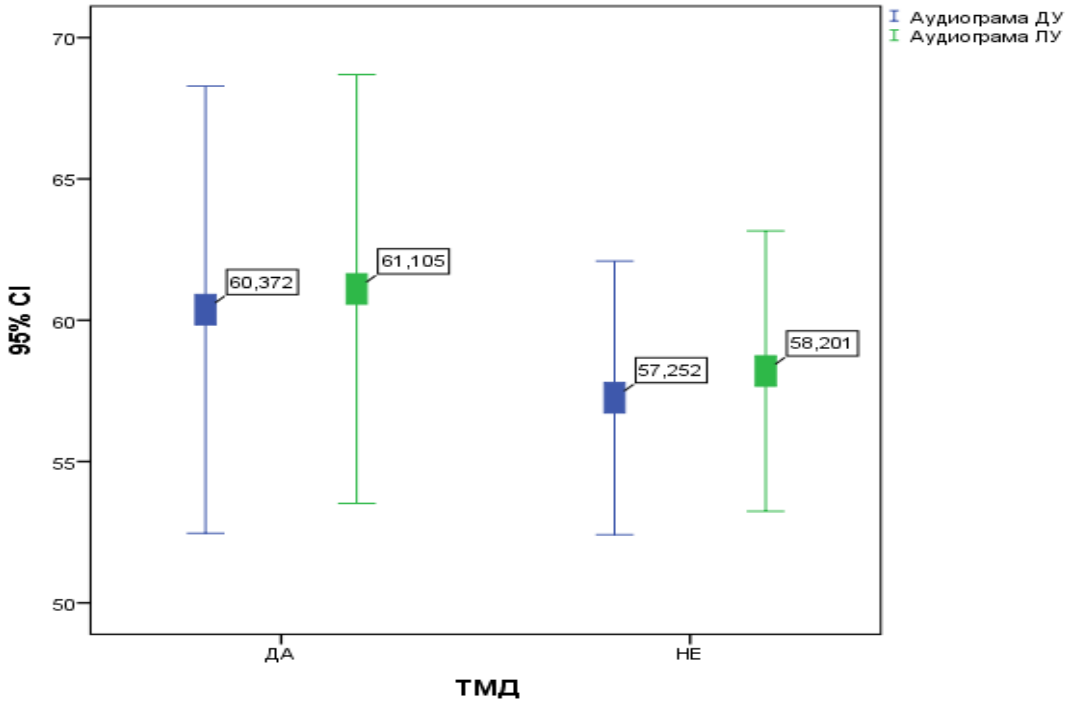

Fig. 48. Mean value of audiogram results

In a more detailed analysis of the degree of hearing loss in patients with TMD, it was found that there is a difference between the two ears, as the right ear is more affected ($p < 0.05$) (Fig. 49)

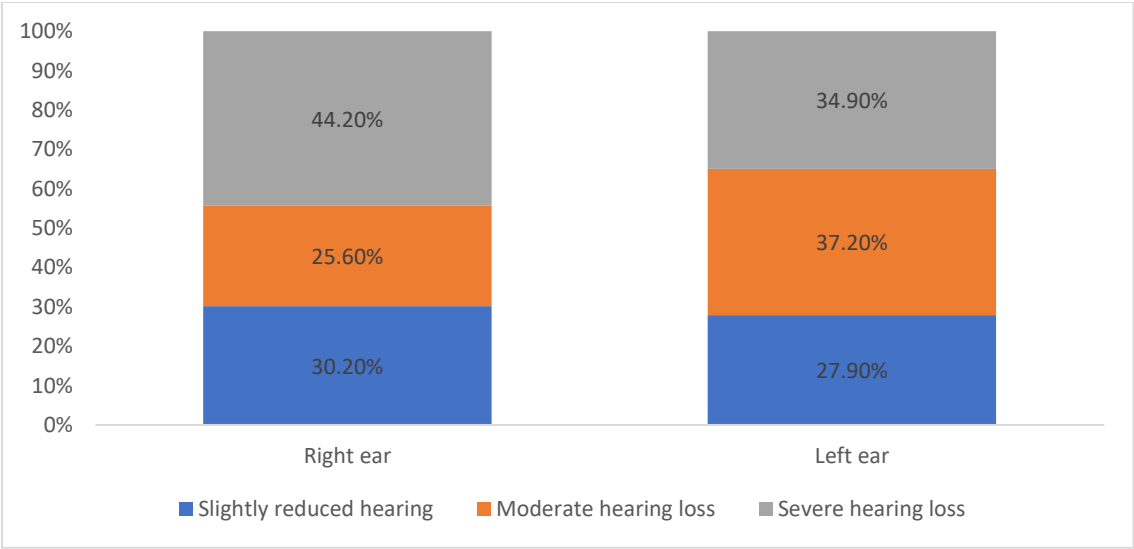

Fig. 49. Degree of hearing loss in both ears in patients with TMD

The results of the analysis of the audiograms show the same trend as the tympanograms at the examined points. Despite the variation of the mean values of the audiograms in the detected pain in point 1 no statistically significant difference was observed (Fig. 50).

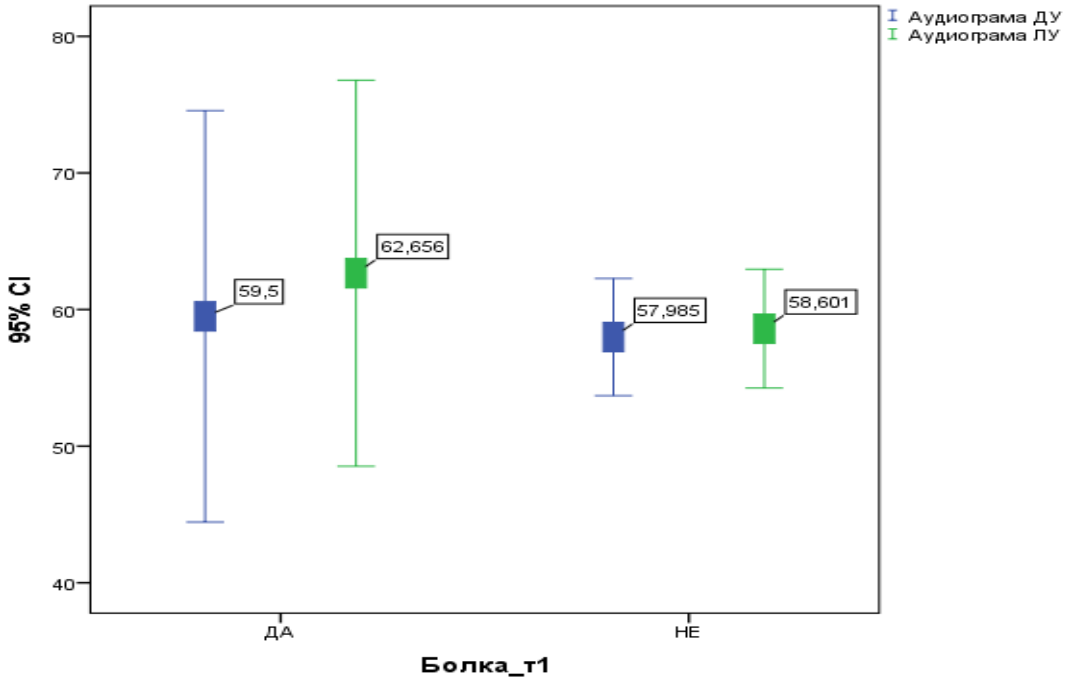

Fig. 50. Mean value of the results of the audiogram for pain in point 1

In patients with morning rigidity, a significant difference in hearing loss was found between the right and left ear ($p = 0.045$), indicating that in these patients the left temporomandibular joint was significantly more affected than the right (Fig. 51).

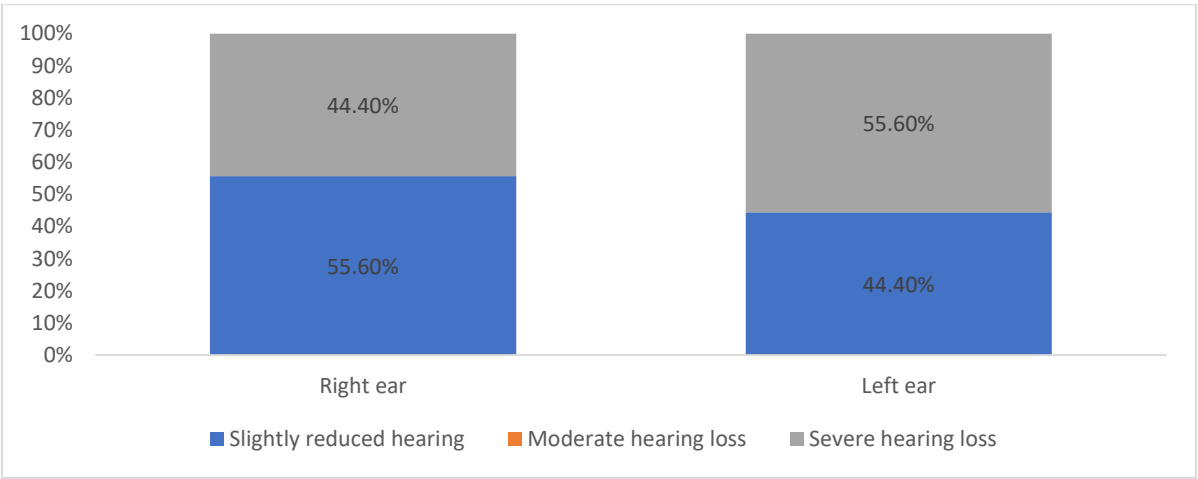

Fig. 51. Degree of hearing loss in both ears in patients with morning rigidity

Pain during chewing is associated with moderate to severe hearing loss ($p = 0.028$) in both the right and left ear, indicating that both TMJ may be affected by this symptom (Fig. 52).

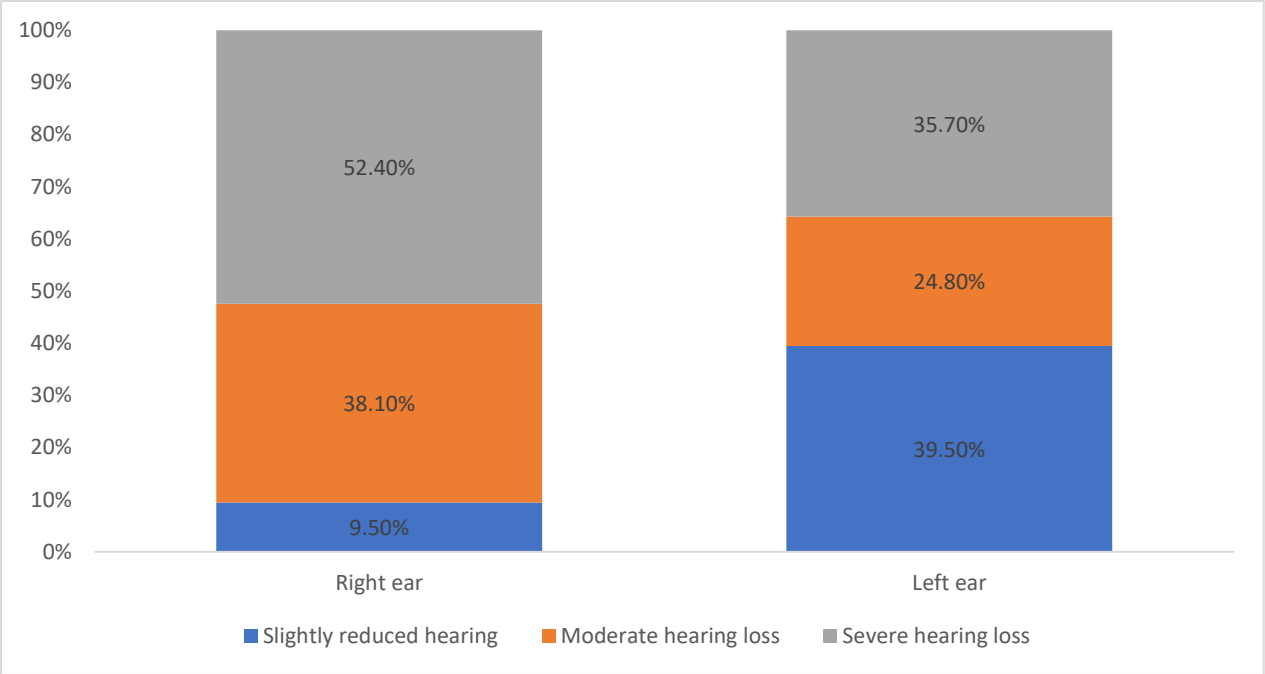

Fig. 52. Degree of hearing loss in both ears in patients with chewing pain

Trismus was associated with severe hearing loss in both ears (r = 0.241; p = 0.003), with the right ear being more common in the present study (p = 0.006) (p = 0.006) (Fig. 53).

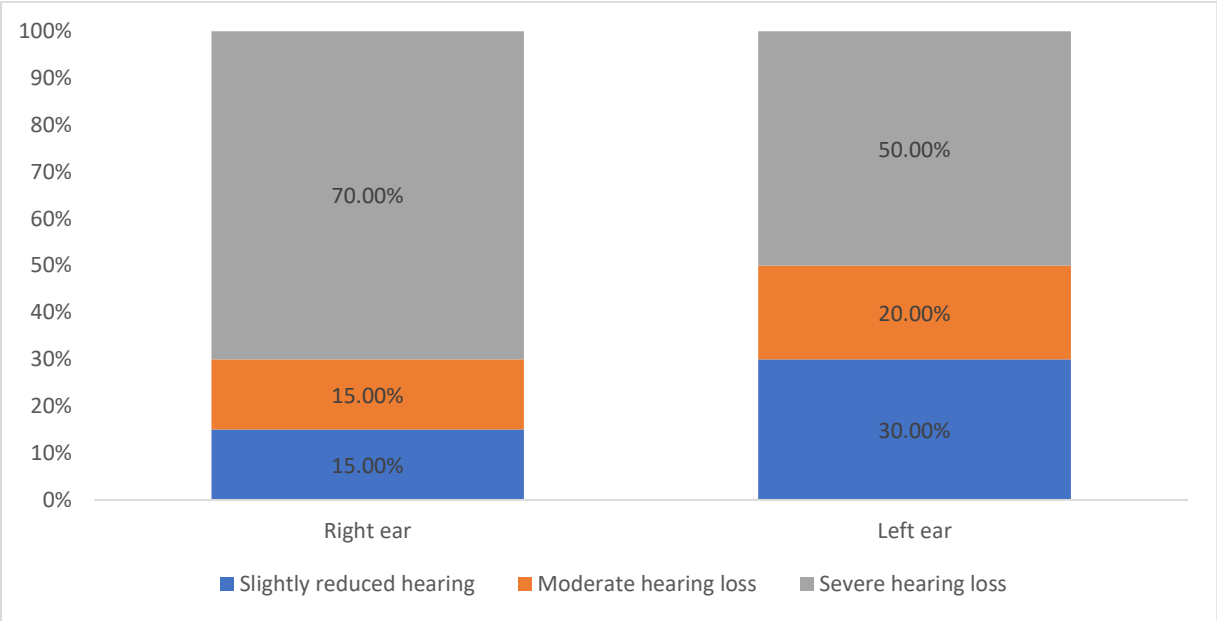

Fig. 53. Degree of hearing loss in both ears in patients with trismus

Discussion on the task:

The main findings of our study, suggesting that TMD increases the risk of tinnitus, are consistent with current studies.

This suggests that pathological changes in TMJ play a crucial role in the development of tinnitus. Senile changes, hearing loss and male sex are confirmed as risk factors for the development of tinnitus. However, our findings show that female patients with TMD have a higher risk of tinnitus than men with TMD.

Studies have shown that changes in the course of the trigeminal nerve caused by TMJ dysfunction can cause disturbances in the activity of the dorsal cochlear nucleus, which can affect the central auditory pathway and lead to tinnitus.

To prepare a risk profile of patients with tinnitus and TMJ dysfunction

From the conducted analyzes so far, several main factors have been identified, which are related to the increased risk of TMD, with the presence of parafunction (bruxism) being the strongest (Table 6).

Table 6. Risk profile of patients with tinnitus and TMJ dysfunction

Risk factor	OR	95 % CI	P value
Parafunction - bruxism	20.952	2.702-162.469	< 0.001
Joint disease	3.477	1.241-9.741	0.018
Prosthetic treatment performed	2.54	1.003-6.407	< 0.05
Complete edentulousness	2.124	1.030-4.381	< 0.05

Table. 7 presents the relative share of patients with TMD who have problems with tinnitus. The table shows that the risk of parafunction (bruxism, bruxomania) is the most important factor in the presence of tinnitus, followed by the presence of joint disease. Third is the lack of prosthetic treatment if necessary and complete edentulousness.

Table 7. Relative share of patients with TMD and tinnitus problems (n = 43)

Questions	**Number/%**
I feel the noise from waking to falling asleep	7/16.3%
Because of the noise, I'm afraid I have a serious health problem	22/51.2%
If the noise continues, it's not worth living	2/4.7%
Because of the noise I am more irritable in the family and with friends	24/55.8%
I am afraid that the noise may damage my physical health	20/46.5%
I have a hard time resting because of the noise	19/44.2%
Often the noise is so annoying that I can't ignore it	22/51.2%
I find it harder to fall asleep because of the noise	14/32.6%
I feel exhausted because of the noise	17/39.5%
I often wonder if the noise will ever go away	18/41.9%
I am a victim of noise	6/14.0%
Noise affects my concentration	23/53.5%

According to the analysis of the completed questionnaires, the largest percentage of patients with tinnitus (55.8%) complain of greater irritability when they are in their social area. Complaints about difficulty concentrating (53.5%) followed, and an equal number said that noise was so unpleasant that they could not ignore it and even linked it to a serious health problem (51.2%). According to 46.5% of patients, noise could severely damage their physical health. 44.2% find it difficult to rest due to the presence of tinnitus. Many patients with tinnitus

doubt whether this noise will ever disappear - 41.9%. According to 39.5%, noise is the reason for their exhaustion. 32.6% reported sleep problems due to tinnitus. All-day tinnitus is typical for 16.3%. 14% feel victimized by this noise, and 4.7% think it is not worth living if this noise continues.

Discussion on the task:

Our results coincide with those of most authors, who believe that bruxism is the main etiological factor of temporomandibular dysfunction. The data obtained differ from the findings that various joint diseases or traumatic injuries leading to laterognathia and other bite problems and thus disrupting occlusal relationships are the main cause of temporomandibular dysfunction.

The deteriorating quality of life in patients with tinnitus is discussed by most authors working on the issue. Each of them gives a different predominance over the different nuances of this quality. According to our study, mostly commented on irritability and lack of concentration. While other authors point to sleep disturbances and feelings of exhaustion are the main complaints of patients with tinnitus.

To create an algorithm for the diagnosis of patients with tinnitus and TMJ dysfunction and to closely specialize the diagnostic protocol of TMD in collaboration with an ENT specialist.

The development of an algorithm for the diagnosis of patients with tinnitus is extremely important because the unclear etiology of the disease delays treatment and prolongs the discomfort of patients suffering from tinnitus (Fig. 54). Diagnostic and therapeutic treatment of tinnitus is a challenge for various reasons. Many etiological factors can lead to the same phantom perception of sound.

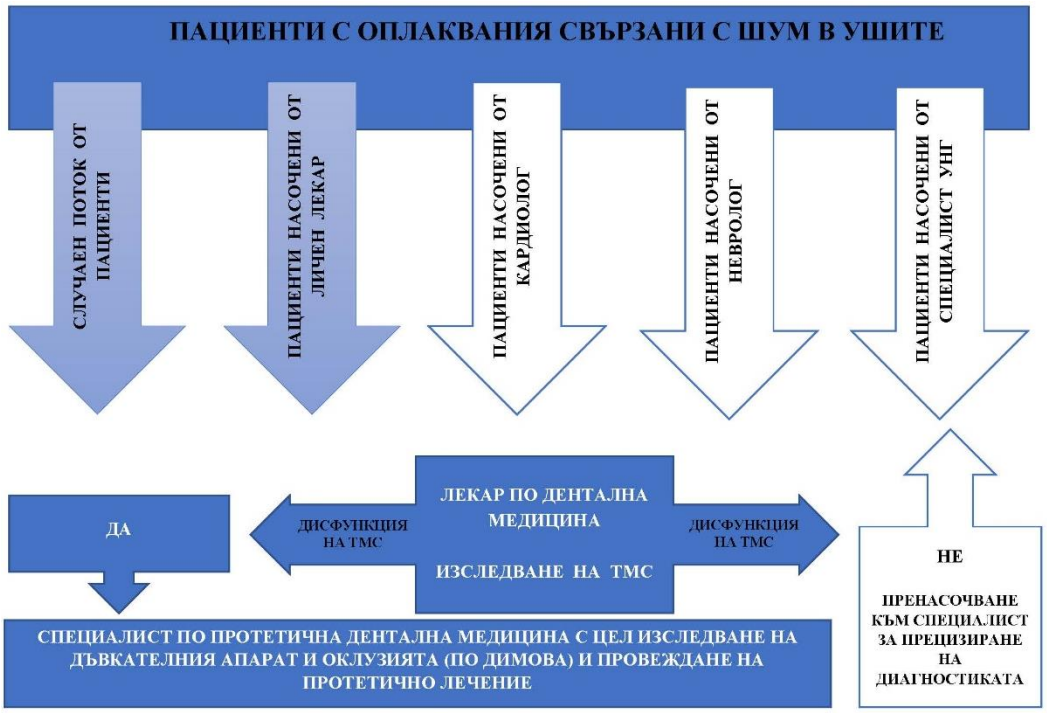

Fig. 54. Algorithm for the diagnosis of TMD in patients with complaints of tinnitus

Discussion on the task:

Although hearing impairments are the most important risk factors for the development of tinnitus, other diseases such as brain tumors, neck injuries, temporomandibular dysfunction or emotional disorders, usually covered by other disciplines (eg neurology, psychiatry, orthopedics, cardiology, dentistry or neurosurgery), may be critically involved in the etiology and diagnostics of tinnitus. Therefore, the requirements for comprehensive diagnosis and treatment of tinnitus can only be met through an integrated multidisciplinary approach.

Although tinnitus is not dangerous, it can be the first sign of potentially dangerous diseases that can even become life-threatening if left undiagnosed and untreated. In addition, tinnitus itself can be life-threatening if it is accompanied by suicidal tendencies.

A step-by-step approach to the diagnosis of tinnitus is proposed, starting with basic diagnostic steps recommended for all patients, and includes collecting anamnestic data for tinnitus-related symptoms by examination from various medical professionals, including general practitioners, doctors and dentists.

Depending on the findings after the first step, additional diagnostic or therapeutic measures are often needed.

The second step consists of referral to a dentist, preferably a prosthetic dentist, for a detailed examination of the TMJ to determine the presence or absence of temporomandibular dysfunction.

Adequate diagnosis should be accompanied by interdisciplinary consultation.

The first step should be performed in each patient and does not require any complex tools, will reveal enough clinical information about tinnitus and concomitant diseases to decide whether additional diagnostic measures such as referral to a dentist are needed.

In case of proven dysfunction of TMS, patients are referred to a specialist in prosthetic dentistry in order to examine the masticatory apparatus and occlusion according to Dimova and, if necessary, prosthetic treatment.

If no temporomandibular dysfunction is detected, patients are referred with the results of the dental examination to the referring specialists in order to continue the search for the cause of tinnitus. Patients who have tinnitus and are primary to the dentist or are referred to him by a general practitioner, and if they do not find TMD, are referred to an ENT specialist.

The algorithm developed in this way shortens the path to making an accurate diagnosis, which is the basis of adequate treatment (Fig. 55).

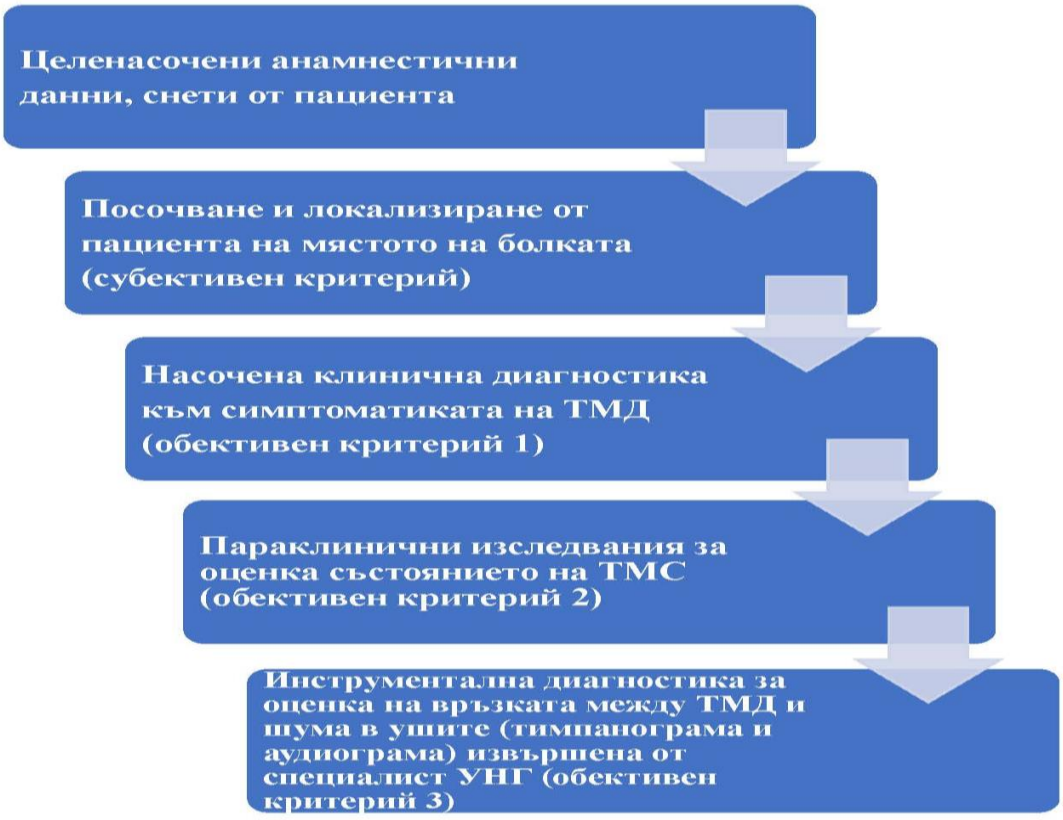

Fig. 55. Specialized diagnostic protocol of TMD

Discussion on the task:

Specialized diagnostic protocol of TMD in collaboration with ENT specialist:

1. Targeted anamnestic data taken from the patient

Targeted anamnestic data include data on the presence of parafunction, complete edentulousness, the presence of joint disease, facial asymmetry in the conduct of dental examination.

2. Indication and localization by the patient at the site of pain (subjective criteria)

Information from the patient about the presence of pain at rest, when speaking, when chewing; clicking; morning rigidity; trismus.

3. Targeted clinical diagnosis of the symptoms of TMD (objective criteria)

Objective study of pain in the area of TMJ, examined in five points.

4. Paraclinical examinations

Referral of patients to X-ray examination to optimize the diagnosis (Fig.56 and Fig. 57).

5. Instrumental diagnostic tests (audiometry, tympanometry)

Fig. 56. Patient N.D. 62 years old - Data on bilateral subluxation in the temporomandibular joints

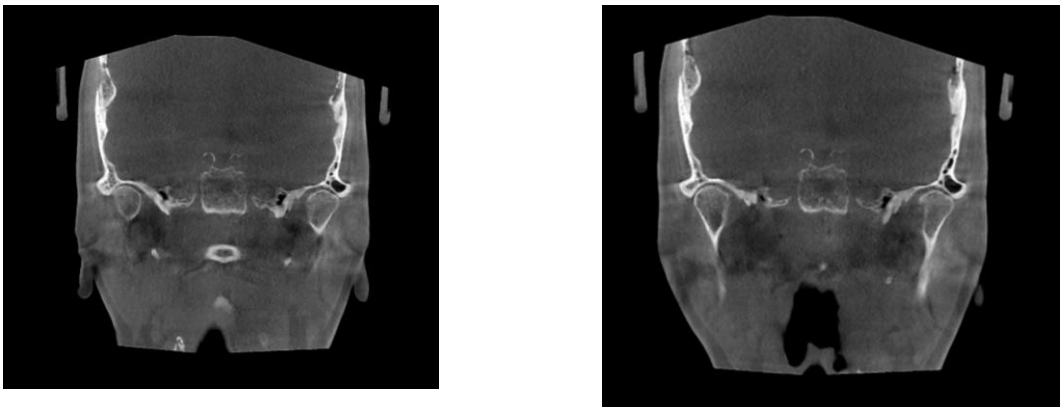

Fig. 57. Patient G.F. 52 years - CBCT coronary sections of both TMJ - suspected bilateral compression in the joints. Normal bone structure.

Referral of the patient to an ENT specialist to assess the correlation between TMD and tinnitus through audiometry, tympanometry.

CONCLUSIONS

In connection with the aim of the study to evaluate the relation between problems in the temporomandibular joint and tinnitus in patients with audiovestibular diseases, the following conclusions can be made:

From the demographic surveys carried out for the first task it is established that:

- The studied patients were on mean age 60.5 years ± 12.8 years (25 years - 90 years), as about 2/3 (62.5%) of them are women. The mean age of women is 59.4 years and that of men is 62.3 years.
- Of the patients studied, only 5.9% were diagnosed with bruxism, with a predominance of women (66.7%).
- TMJ dysfunction was found in 27.6% of patients, mostly women (66.7%).
- The majority of patients with TMD are symptomatic, with a predominance of female patients (66.7%). In men, complaints are less common. Men without complaints are more than those with complaints (39.10% / 33.30%).
- There was a significant difference in the type of prosthetic treatment and complaints related to TMJ dysfunction ($p = 0.030$), finding that the likelihood of TMJ dysfunction in patients with complete dentures increased more than twice (OR = 2.124 (1,030-4,381); $p < 0.05$)
- It was found a directly proportional moderate relation between bruxism and TMJ dysfunction ($r = 0.344$; $p < 0.001$), with bruxism being responsible for 19.0% of TMJ dysfunction cases in the present study. On the other hand, bruxism is considered a risk factor for TMJ dysfunction, and its presence increases the risk of such dysfunction by about 21 times (OR = 20,952 (2,702-162,469); $p < 0.001$)
- 11.2% of the examined patients have joint diseases, and a proportionally weak dependence with TMJ dysfunction was found ($r = 0.201$; $p = 0.013$). In the present study, joint disease was associated with 21.4% of cases of TMJ dysfunction. On the other hand, the presence of joint disease can be considered as a risk factor for TMJ dysfunction, with the risk increasing more than 3 times (OR = 3.477 (1.241-9.741); $p = 0.018$)

After the research on the second task, it became clear that:

- The mean age of patients with tinnitus is 58.5 years ± 13.5 years, with a minimum of 25 years and a maximum of 78 years.
- The most common noise is similar to whistling (36.4%), followed by buzzing (22.8%). On the other hand, 87 (58.0%) patients reported that tinnitus is unilateral only in the left or right ear, and in the others the noise is in both ears.
- Women are more sensitive to tinnitus, with a significant difference in the mean estimate of tinnitus between the sexes ($p < 0.001$). Patients in need of prosthetic treatment have a higher assessment of tinnitus ($p = 0.067$).
- More than ¾ of the examined patients indicated that they felt tinnitus from the moment of waking up to falling asleep, and there was no difference in the opinion of the patients according to gender and the performed prosthetic treatment.
- About 2/3 (65.3%) of the patients state that they are more irritable in their relations with family and friends due to tinnitus.
- There was a significant difference in irritability due to tinnitus between men and women ($p < 0.001$), with this indicator moderately correlated with female gender ($r = 0.380$; $p < 0.001$).
- About 3/7 (73.3%) of the surveyed patients state that they are afraid that the tinnitus may harm their physical health, without establishing a connection with gender and the performed prosthetic treatment.
- About 62% said they found it difficult to rest because of tinnitus, with a significant difference and moderate gender dependence ($r = 0.358$; $p < 0.001$), with gender finding that women had a harder time falling asleep than men. (88.5% for women and 58.2% for men, respectively; $p < 0.001$)
- Men feel more exhausted than women because of tinnitus (52.0% for men and 42.3% for women, respectively; $p = 0.002$).
- The concentration of women is significantly more affected by tinnitus than the concentration of men (88.5% for women and 58.2% for men, respectively; $p < 0.001$.

After the research on the third task we can conclude that:

- 28.7% of the studied patients with tinnitus were diagnosed with TMD dysfunction.
- The main complaints of patients that may be associated with TMJ dysfunction. The most common are pain in speech (16.00%), followed by clicking of the TMJ (15.3%) and pain in chewing (14.00%).
- A significant gender difference was found with regard to the clicking of the TMJ, which is more frequent in women (10.2% for men and 25.0% for women, respectively; $p = 0.017$).
- Another difference was found in pain at rest ($p = 0.047$), where 19.2% of women and 9.2% of men had similar complaints.
- It was found that the lack of prosthetic treatment in patients in need of such treatment leads to an increase in the risk of pain at rest by 2.23 times (OR = 2.23 (0.824-6.014); $p < 0.05$).
- In patients in need of prosthetic treatment, chewing pain is more common (20.3% versus 8.6%) ($p = 0.035$).
- Prosthetically untreated patients are at 2.69-times higher risk of chewing pain (OR = 2.69 (1.018-7.113); $p < 0.05$).
- The clicking of the TMJ is another factor that is influenced by the prosthetic treatment, as its frequency is 21.7% among the patients who did not receive treatment, but needed it. The incidence was 9.9% in those treated ($p = 0.037$). The lack of prosthetic treatment was found to increase the risk of TMJ clicking by 2.54 times (OR = 2.54 (1.003-6.407); $p < 0.05$).
- In patients who report morning rigidity in the joint, pain is reported on palpation, mostly in p. 4, followed by p. 2.
- The pain in p. 4 is associated with compression of the TMJ as a result of night clenching of teeth in patients with bruxism and bruxomania.
- The pain in p. 2 is indicative of increased tone of the m.pterygoideus lateralis, which is activated by parafunctional movements in the temporomandibular joint.
- Pain at rest is associated with pain on palpation of points 1 to 4 ($p < 0.001$).
- Morning rigidity correlates most strongly with pain in p. 4 (0.367), followed by pain in p. 2 (0.339).
- Pain at rest shows the strongest relation with pain in p. 4 (0.405), followed by pain in p. 1 (0.388) and p. 2 (0.381).

- Pain during speech has the strongest relation with pain in p. 2 (0.447), followed by that in p. 5 (0.301). The pain during chewing correlates mainly with the pain in p. 2 (0.354).
- The clicking of the TMJ correlates with almost all points except for p. 5., as in p. 2 and p. 3 the dependence is the strongest (0.461). Trismus shows a strong dependence on pain in p. 3 (0.437) and p. 5 (0.431).
- There was a significant difference between the severity of tinnitus in pain found in p. 4 (p= 0.047), with a predominance of patients with third degree (41.7% to 37.7%).
- The third degree of severity of tinnitus correlates with the pain found in p. 4 (r = 0.238; p= 0.020). No connection with gender and prosthetic treatment done was found.
- All patients who underwent tympanogram showed results in the norm of the right ear, as the average values were -31.7 daPa ± 32.7 daPa (from -143.0 daPa to 7.0 daPa), and in 6 patients there was a deviation from the norm above - 150 daPa in the left ear, with an average value of -35.0 daPa ± 39.8 daPa (-152.0 daPa to -6.0 daPa).
- There was no significant difference in tympanogram results according to the presence of TMJ dysfunction, but there was a moderate relation between tympanogram results and the severity of tinnitus in patients with TMS dysfunction (r = -0.419; p = 0.012).
- The pain in point 5 was associated with high values of the audiogram in both the right and left ear (p <0.05). However, half of the patients had a mild degree of hearing loss in the left ear, while 62.5% had a severe degree of hearing loss in the right ear (p <0.05).
- Pain during chewing is associated with moderate to severe hearing loss (p = 0.028) in both the right and left ear, indicating that both TMJ may be affected by this symptom.
- Trismus was associated with severe hearing loss in both ears (r = 0.241; p = 0.003), with the right ear being the most common in our study (p = 0.006).

After the research on the fourth task we can conclude that:

- The risk of parafunction (bruxism, bruxomania) is the most important factor in the occurrence of tinnitus, followed by the presence of joint disease. Third is the lack of prosthetic treatment if necessary and complete edentulousness.

- The highest percentage of patients with tinnitus (55.8%) complain of greater irritability when they are in their social area. Complaints about difficulty concentrating (53.5%) followed, and an equal number said that the noise was so unpleasant that they could not ignore it and even linked it to a serious health problem (51.2%).
- According to 46.5% of patients, tinnitus could severely damage their physical health. 44.2% find it difficult to rest due to the presence of tinnitus. Many patients with tinnitus doubt whether this noise will ever disappear - 41.9%. According to 39.5%, tinnitus is the reason for their exhaustion. 32.6% reported sleep problems due to tinnitus. All-day tinnitus is typical for 16.3%. 14% feel like a victim of this noise.

In connection with the fifth task, it can be concluded that:

The development of an algorithm for the diagnosis of patients with tinnitus is extremely important because the unclear etiology of the disease delays treatment and prolongs the discomfort of patients suffering from tinnitus.

CONCLUDING REMARKS:

1. Some of the examined prosthetic patients suffer from bruxism and/or bruxomania related to dysfunctions in the temporomandibular joints.
2. The probability of developing TMJ dysfunction in completely edentulous patients is twice as high as in those who need partial prosthetics.
3. Tinnitus has a direct impact on the mood, habits and deteriorates the quality of life of patients, which is why timely diagnosis and treatment of this condition are a priority.
4. There is a direct link between tinnitus and temporomandibular dysfunction, which argues the importance of a detailed study of TMJ and the introduction of a diagnostic protocol in patients with tinnitus.
5. According to the established risk profile of patients with tinnitus and TMD, the most important etiological factors are bruxism, followed by the presence of joint disease and the lack of prosthetic treatment, if necessary, with complete edentulousness.
6. The need for timely diagnosis and treatment of patients with tinnitus requires the creation of an algorithm for the diagnosis of these patients and their referral to a specialist, emphasizing the role of the dentist in cases where there is TMD.
7. The detailed examination of TMS in the five described points assists dentists in diagnosing patients with tinnitus with regard to temporomandibular joint dysfunction as a risk factor.

CONTRIBUTIONS

Original for the country:

1. For the first time in Bulgaria, the relation between temporomandibular dysfunction and tinnitus has been subjected to critical analysis and recommendations for dental practice have been made.

With practical application:

1. Optimization of the interdisciplinary approach for diagnosis of patients with tinnitus through the algorithm created by us.
2. A protocol for detailed examination of TMJ has been proposed, including objective and subjective criteria, which assists dentists in the differential diagnosis of patients with tinnitus.

With theoretical application:

1. A detailed risk profile of patients with tinnitus has been developed.

Confirmatory:

1. The correlation between tinnitus and temporomandibular joint dysfunction was confirmed.
2. It has been confirmed that tinnitus worsens the quality of life of patients.

LIST OF PUBLICATIONS RELATED TO THE DISSERTATION:

1. Borisov B. Demographic Characteristics of Patients with Temporomandibular Joint Dysfunction. International Journal of Science and Research (IJSR), Volume 11 Issue 2, February 2022, 102 – 104.

2. Borisov B. Risk Profile of Patients with Tinnitus and TMJ Dysfunction. International Journal of Science and Research (IJSR), Volume 11 Issue 2, February 2022, 97 – 99.

3. Borisov, B., Milkov, M., Stoykov, M., & Dimova, E. (2021). Tinnitus–a manifestation of neurodegenerative diseases. International Bulletin of Otorhinolaryngology, 17(3), 28-32.